Vol. XXVII, Part III September 1957

THE INDIAN JOURNAL OF AGRICULTURAL SCIENCE

सत्यमेव जयते

THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH

NEW DELHI

1958 (see back cover)

Vol. XXVII, Part III September, 1957

THE INDIAN JOURNAL OF AGRICULTURAL SCIENCE

ISSUED UNDER THE AUTHORITY

OF

THE INDIAN COUNCIL OF AGRICULTURAL RESEARCH

सत्यमेव जयते

Annual subscription
Rs. 10 or 16sh.

Price per part
Rs. 2·50 nP. or 4sh.

ICAR. 5. XXVII. 3
2,300

DEVELOPMENT STUDIES IN CROP PLANTS

II—EFFECT OF CULTURAL TREATMENTS ON THE INCIDENCE OF GRAM WILT

By P. C. RAHEJA and G. P. DAS, Indian Agricultural Research Institute, New Delhi

[Received for publication on December 31, 1955
Accepted for publication on September 18, 1956]

(With 2 Text Figs.)

FUSARIUM orthoceras var. Ciceri is one of the most important soil borne fungi causing immense loss to gram crop over many years. Howard, Heward and Khan [1915] were of the opinion that the contributing cause of the wilt in Pusa soil appeared to be the inhibition of air supply in the nodules and root system on account of the soil crust formed by rains. Dastur [1935] reported that in the Central Provinces (Madhya Pradesh) the diseases of gram comprised two important wilts. One of them was associated with a species of *Rhizoctinia* while the other was shown by the field experiments to be physiological in nature. The latter appears on plants at any stage of their growth. Padwick [1940] observed that the disease was correlated with high temperatures during the stages of germination and early growth. Late sowing accompanied by a fall in temperature, reduced the incidence of wilt. Padwick and Bhagwagar [1943] reported results of experiments conducted on gram at Indian Agricultural Research Institute, New Delhi, over four seasons. The crops were sown at weekly intervals commencing from September 23. The wilt decreased in intensity with delayed sowing upto the middle of October with a corresponding increase in the yield of grain. After mid-October the yield of gram tended to decline. Parr [1943 and 1944] observed that optimum time of sowing of gram appeared to be second or third week of October.

The failure of the inoculations with the pathogenic organisms in most cases to produce the wilt disease leads one to the conclusion that they are not always the primary cause of the disease. It appears that soil aeration and soil temperature are important factors in determining the virulence of the pathogens [Rhind 1925 and Dastur 1931 and 1934]. To study the interaction of these factors a cultural experiment on gram with three dates of sowings, two depths of seeding and three spacings in between the rows was laid out on the gram crop in the *rabi* season in 1947-48. Observations were recorded in respect of germination, growth rate, flowering and incidence of wilt.

EXPERIMENTAL

A split plot design experiment with dates of sowing as main plot treatments and a combination of spacings between the rows and the depth of seeding as

sub-plot treatments was conducted in three replications in 1947-48. The treatments were as follows :

Main plot treatments

DATES OF SOWINGS

D_1—October 27 D_2—November 10 D_3—November 24

Sub-plot treatments (1st split)

SPACING BETWEEN ROWS

S_1—10 inches S_2—15 inches S_3—20 inches

Sub-sub-plot treatments

DEPTH OF SEEDING

d_1—$2\frac{1}{2}$ inches d_2—5 inches

The sowings were done on the conserved moisture of the preceding monsoon season.

Germination

Observations were recorded on germination to note the number of days taken by the plants to emerge and the number of days these plants take to complete the process of germination. These data are recorded in Table I. The time of germination varied and the completion of germination took longer time as the sowing was delayed. This was due more to the temperature factor than the soil moisture factor.

TABLE I

Time taken to complete germination

Date of sowing	Dates when first shoots were observed	Dates by which germination completed	Days taken to complete germination	
			After sowing	After start
Oct. 27	Nov. 2	Nov. 6	10	4
Nov. 10	Nov. 16	Nov. 21	11	5
Nov. 24	Dec. 2	Dec. 9	15	7

The delayed germination, however, did not affect the stand of the crop.

Stand

The observations on the stand of the crop were taken after 23 days of the each sowing date. For this purpose the actual number of plants in one row out of five, selected at random in each plot, was counted. The figure provided an average population per row from which the stand of the crop was calculated. The data are summarised in Table II.

TABLE II

Stand of the crop in relation to different treatments

Treatments	Seed rate per acre (seers)	Stand per row	Genl. mean No. of plants per plot (=0·018 Acres)	SEm	CD at 5 per cent	Conclusions
Dates of sowing						
D_1= October 27	22·75	107·6	2151·7			
D_2=November 10	22·75	111·5	2210·4	±199·3	'F' not sig.	$D_3D_2D_1$
D_3=November 24	22·75	150·4	3007·5			
Spacing between rows						
S_1=10 inches	31·5	115·7	3477·7			
S_2=15 inches	21·0	117·8	2356·4	± 83·2	271·1	$S_1>S_2>S_3$
S_3=20 inches	15·75	102·4	1535·5			
Depth of seeding						
d_1=2½ inches	22·75	117·5	2250·1	± 99·7	325·3	$d_2>d_1$
d_2=5 inches	22·75	133·1	2663·0			

NOTE. Treatments in the column "conclusions" are arranged in a descending order of the magnitudes of their means. Non-significant groups are marked by a horizontal line drawn above them.

While the mean difference for the dates of sowing were not statistically significant, with delayed sowing, owing to fall in temperature, the germination improved, so that the stand of the crop sown on 24th November was significantly superior to the preceding two sowings as shown by the significance of the linear function — $2D_3—D_1—D_2$.

Significant differences in the number of plants per plot were noticed in the three spacings. The maximum number of plants per plot were observed in 10 inches spacing between rows. This is as it was expected. The differences between S_1 and S_2 and between S_2 and S_3 were significant. The stand per row worked out as 115·9, 117·8 and 102·4 plants respectively. The difference in the population was in favour of deep sown seed which was significant. It is probable that moisture status was better at 5 inches depth than at the shallow depth of $2\frac{1}{2}$ inches of seeding.

Cumulative growth in length

With a view to study the relationship between the incidence of wilt and the vigour of plants systematic observations on growth in length were recorded. The plants in each of the plots of a replication were labelled. These were from the five central rows. The vertical distance from the base of the plant, previously marked with India ink, to the top-most axil of the stem had been measured in each plant at different intervals. The measurements were recorded at weekly intervals. The mean values of growth arranged treatmentwise are given in Table III as under :

TABLE III

Cumulative growth in length in cm. on different dates

Treatments	Dates of observation										
	29/12	11/1	18/1	25/1	1/2	8/2	15/2	23/2	29/2	7/3	14/3
Dates of sowing											
Oct. 27	21·2	29·5	32·1	36·1	40·9	43·9	48·2	53·3	56·6	60·3	62·4
Nov. 10	14·3	19·1	22·1	25·4	28·9	35·6	40·7	46·7	50·4	55·1	57·4
Nov. 24	7·0	9·6	10·6	14·0	18·2	24·7	30·9	38·3	41·7	46·9	50·4
Spacing between rows											
10″	14·2	19·7	21·7	25·2	30·8	35·8	41·3	46·5	49·8	54·6	57·0
15″	14·4	19·6	21·8	25·2	30·1	34·9	40·1	47·1	49·4	55·2	57·7
20″	13·8	19·6	21·2	24·5	28·8	30·0	40·0	44·9	48·6	52·5	55·7
Depth of seeding											
$2\frac{1}{2}$″	13·7	18·6	21·0	24·5	28·7	33·6	39·1	44·9	47·5	53·6	54·3
5″	14·6	20·2	22·1	25·8	30·8	34·9	40·7	47·4	50·7	54·8	57·3
(i) *Wilted plants*	18·8	25·6	28·5	32·2	37·3	40·8	45·2	51·1	54·1	58·4	60·6
(ii) *Healthy plants*	13·0	17·7	19·8	23·7	28·0	33·2	38·6	44·9	45·5	53·1	56·2

From these data the growth curves for different dates of sowings and wilted and healthy plants, which showed wide differences in their cumulative growth in length at successive stages, were fitted in accordance with the equation—

$$H=Ae^{bt}$$

Where H=height in cm., A=a constant representing the initial potential of growth, t=time in days, and b=the relative growth rate of efficiency index of the plant. The calculated values of H have been presented in Table IV.

TABLE IV

Calculated cumulative growth values in cm. from fitted curves

Treatments	Dates of observations										
	29/12	11/1	18/1	25/1	1/2	8/2	15/2	23/2	29/2	7/3	14/3
Dates of sowing											
Oct. 27	24·5	29·0	31·8	34·8	38·1	41·7	45·7	50·7	54·8	60·1	65·8
Nov. 10	15·5	19·8	22·7	25·9	29·6	33·8	38·6	44·9	50·3	57·5	65·6
Nov. 24	7·1	10·2	12·5	15·2	18·4	22·4	27·2	34·0	40·3	49·0	59·6
Wilted plants	21·3	25·9	28·8	31·9	35·5	39·4	43·8	49·3	54·0	60·0	66·5
Healthy plants	14·3	13·2	20·8	23·7	27·01	31·0	35·3	41·1	46·1	52·7	6·01

These data have been graphically represented in Figs. 1 and 2. The growth constants of the fitted curves are given in Table V.

TABLE V

Constants of the fitted growth curves

Treatments	Constant 'A'	Constant 'b'	S. E. of 'b'	Remarks
Date of sowing				
D_1—Oct. 27	24·5	0·013	±0·0003902	Differences in 'b' values significant $D_3 > D_2 > D_1$
D_2—Nov. 10	15·5	0·019	±0·0003974	
D_3—Nov. 24	7·1	0·028	±0·0006703	
Spacings				
S_0—10 inches	14·99	0·01892	±0·0007545	Not Sig.
S_0—15 inches	15·06	0·01885	±0·0008871	
S_2—20 inches	14·51	9·01873	±0·0007991	
Depth of seeding				
D_1—$2\frac{1}{2}$ inches	14·39	0·01889	±0·0007996	Not Sig.
D_2—5 inches	15·39	0·01857	±0·0007899	
Wilted plants	21·3	0·015	±0·0003979	Differences in 'b' values not significant
Healthy plants	14·2	0·019	±0·0004147	

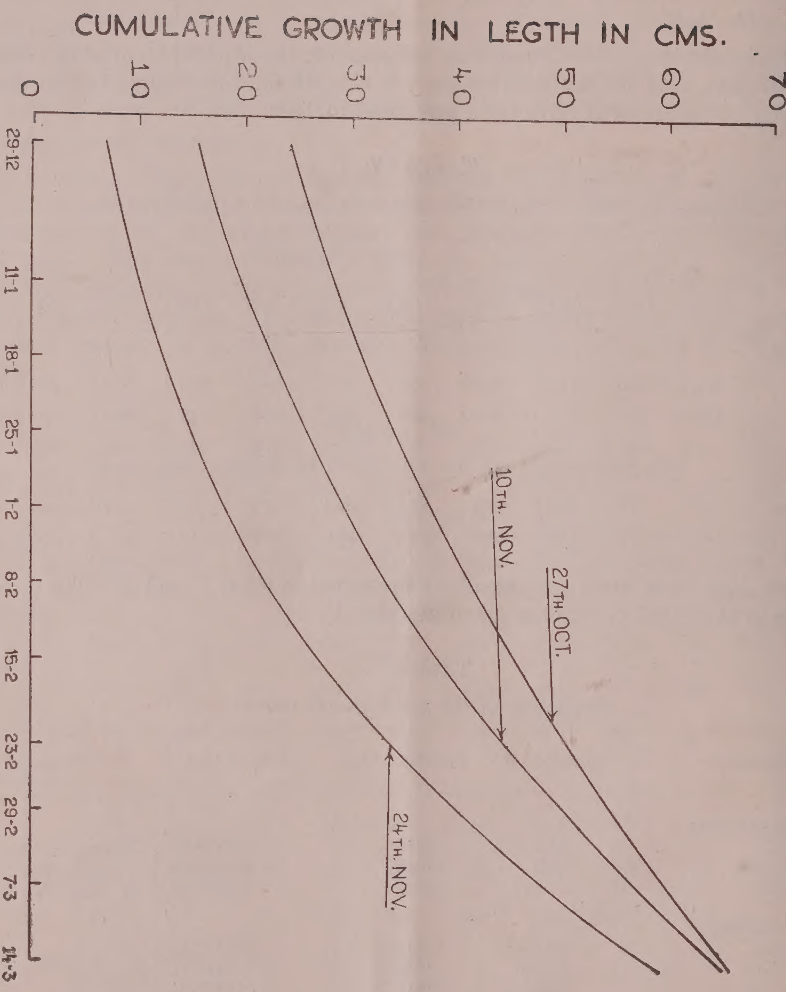


FIG. 1.—CALCULATED CUMULATIVE GROWTH CURVES DATES OF SOWING EFFECT.

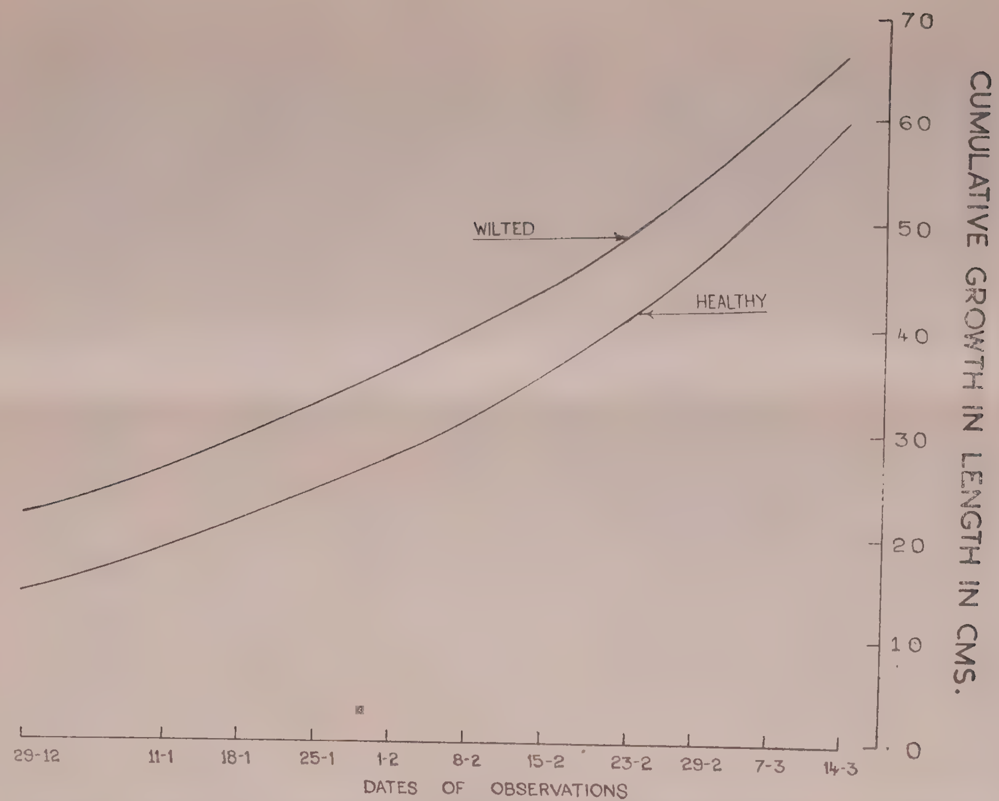


FIG. 2. CALCULATED CUMULATIVE GROWTH CURVES HEALTHY VS. WILT SUSCEPTIBLE PLANTS.

The differences in 'b' values between the different sowing dates were significant. The relative rate of growth was higher in D_3 than either in D_1 and D_2, although the initial differences in growth were in favour of early sown crop. It is noted that differences in relative growth rates of healthy and wilted plants were not significant. The difference of 7·1 cm. in initial growth narrowed down to 4·4 cm.

Rate of flowering

Solitary pink flowers were seen for the first time on the 18th January, in D_1 treatment. Later, within a week flowering could be recorded in D_2 and finally in D_3 treatment. Ten plants at random in each of the plots were labelled for studies. As the pink colour of the flowers changed to white and could be recognised from the freshly opened flowers on the third day, it was decided to count the number of flowers opened within three days. For the plants which wilted later on, record was maintained upto the date of wilting. The results of these observations are summarised in Table VI.

The above flowering data were statistically analysed from two aspects, namely :

(1) The comparison of total flowering over the period, 1st February to 15th March, 1948 for the different treatments.

(2) The comparison of daily mean and total flowering between the wilted and healthy plants for the different treatments.

The statistical analysis of the data have shown that differences due to dates of sowing (D) and spacing (S) treatments were highly significant ($P=0·01$) while the differences due to depth of seeding(d) treatments did not show significance. The interactions $D \times S$ and $d \times S$ were also significant at 1 per cent and 5 per cent level of significance respectively (Table VII).

Wider spacing and early sowing dates influenced flowering beneficially. With the last date of sowing the flowering was more with closer spacings of 10 in. and 15 in. The flowering was unaffected by spacings with shallower sowing of seed. With deeper sowing there was much more flowering together with wider spacing between the rows.

For direct comparison the mean rate of flowering for each interval was worked out by the mean number of flowers per plant divided by the time interval. Table VIII shows the data of the mean rate of flowering per day per plant for the 36 wilted and 144 healthy plants.

TABLE VI

Flower production in relation to wilt incidence per day

Particulars	Number of plants	Dates of observation													Total No. of flowers per day in 13 intervals	Mean No. of flowers per plant wilted and healthy
		1/2	4/2	7/2	10/2	14/2	17/2	23/2	26/2	29/2	3/3	6/3	9/3n	15/3		
Wilted plants	36	0·2	0·3	0·2	1·1	1·7	9·4	1·6	3·8	6·7	4·3	4·4	5·2	0·6	39·5	38
Healthy plants	144	0·1	0·2	0·1	0·6	0·8	5·0	1·1	2·6	6·2	7·2	6·4	6·4	2·2	37·6	
D_1(W)	22	0·4	0·7	0·5	1·8	2·3	11·2	1·9	5·6	10·3	5·9	5·6	4·6	0·9	51·7	49·7
D_1(H)	38	0·2	0·5	0·2	1·5	1·7	10·4	2·1	4·0	8·8	5·3	5·7	5·0	1·4	47·6	
D_2(W)	13	0	0	0	0·5	0·6	4·1	0·8	1·7	3·3	3·5	2·8	5·2	0·8	23·3	33·2
D_2(H)	47	0	0	0	0·6	1·2	6·4	1·1	2·5	8·3	6·5	7·7	6·5	2·3	43·1	
D_3(W)	1	0	0	0	0	0	2·0	0·5	4·3	2·7	4·0	4·0	5·1	0·3	20·2	23·3
D_3(H)	59	0	0	0	0	0	1·1	0·6	1·3	2·6	3·6	7·5	7·3	2·4	26·4	
S_1(W)	11	0·3	0·4	0·1	0·3	0·4	3·4	0·7	1·8	3·3	3·1	2·3	4·3	0·4	19·3	28·3
S_1(H)	49	0·1	2·5	0·1	0·6	0·8	4·2	1·0	2·6	6·1	4·7	6·0	5·9	2·1	36·7	
S_2(W)	12	0·2	0·4	0·4	1·3	2·3	10·9	1·8	4·2	8·5	5·9	5·2	5·3	0·8	47·2	42·2
S_2(H)	48	0·1	0·3	0·1	0·7	0·7	4·9	1·2	2·8	6·2	5·0	6·8	6·3	1·9	37·0	
S_3(W)	13	0	0	0	1·5	2·3	13·0	2·2	5·0	7·8	4·7	5·5	6·1	0·5	48·6	44·6
S_3(H)	47	0	0	0	0·6	1·0	5·9	1·1	2·5	6·4	4·7	8·8	7·0	2·7	40·7	
d_1(W)	16	0	0·1	0	1·1	2·2	12·2	2·0	3·8	7·2	4·8	4·4	6·0	0·4	44·2	42·5
d_1(H)	74	0·1	0·3	0·1	0·9	1·0	5·1	1·1	2·6	6·4	5·1	7·0	6·4	4·8	40·9	
d_2(W)	20	0·3	0·4	0·3	1·0	1·3	7·2	1·3	3·8	6·3	4·6	4·2	4·6	0·8	36·1	32·0
d_2(H)	70	0	0·1	0	0·3	0·4	3·7	0·9	2·0	4·7	3·5	5·8	15·0	1·6	28·0	

TABLE VII

Differences among treatments in total flowering per plant

Means for D/ in descending order		Means for S/ in descending order	Means for d in descending order			D_1	D_2	D_3		D_1	D_2	D_3		S_1	S_2	S_3
D_1	151·6	S_3 132·8			S_1	118·0	100·7	84·8	d_1	160·4	130·9	90·7	d_1	125·2	125·7	131·2
D_2	122·7	S_2 125·8	d_1	127·4	S_2	170·2	101·7	106·7	d_2	142·8	114·5	80·4	d_2	77·2	126·0	134·5
D_3	85·6	S_1 101·2	d_2	112·6	S_3	166·7	165·7	66·1		±10·1				±10·1		
SEm	±7·2	±7·2		±5·9			±12·5									
C. D. at 5 per cent	20·3	20·3	Not Sig:					35·1	Not Sig					28·7		
C. D. at 1 per cent	26·9	26·9						46·5								

TABLE VIII

Flower production on various dates in two periods

Dates	Period I									Period II			
	1/2	4/2	7/2	10/2	14/2	17/2	23/2	26/2	29/2	3/3	6/3	9/3	15/3
Wilted	0·16	0·26	0·18	1·06	1·72	9·40	1·60	3·76	6·68	4·57	4·43	5·18	0·60
Healthy	0·08	0·19	0·05	0·64	0·79	5·08	1·13	2·70	6·39	4·78	7·08	6·40	2·20

It will be observed that the mean rate of flowering in various intervals upto the middle of February is in favour of wilted plants and thereafter in favour of healthy plants. Obviously plants pre-disposed to wilting have a higher rate earlier in the life cycle of the plants compared to healthy plants which indicated vigour of flowering late in the life cycle.

In order to confirm that the date of flowering were divided into two periods, viz. period I from 1st February to 29th February and period II from 3rd March to 15th March, these were further analysed. The summary of the analysed data is given in Table IX.

Table IX

Treatment effect on difference of flower production of healthy and wilted plants

	Wilted (W)			Healthy (H)			W—H=d		
	Mean W	SE W	n_W	Mean H	±SE H	n_H	Diff. d	± SE d	$t=d/SE_d$
Period I—1st February to 29th February									
D_1	109·36	12·43	22	97·79	7·02	38	11·57	14·28	0·81
D_2	35·85	7·66	13	64·40	5·39	47	—28·56	11·03	2·59**
D_3	30·00	—	1	18·22	2·34	55	11·78	17·48	0·67
S_1	33·64	4·68	11	53·89	5·45	45	—20·25	7·19	2·82**
S_2	98·08	22·78	12	54·73	7·16	48	43·35	23·88	1·82
S_3	104·23	11·67	13	57·30	7·50	47	46·93	15·55	3·02**
d_1	94·25	16·19	16	57·61	5·71	74	36·64	14·36	2·55**
d_2	69·70	12·46	20	52·76	5·29	66	16·94	11·78	1·44
Average	80·61	10·05	36	55·32	3·90	140	25·29	10·78	2·35**
Period II—3rd March to 15th March									
D_1	50·91	4·15	22	60·13	3·66	38	—9·22	5·75	1·60
D_2	38·92	4·81	13	73·77	3 ·01	47	—34·84	6·26	5·57**
D_3	59·00	—	1	68·02	4·44	55	— 9·02	—	..
S_1	34·00	4·79	11	58·40	4·19	45	—24·40	6·36	3·83**
S_2	53·17	5·63	12	66·13	3·02	48	—12·96	6·68	1·94
S_3	51·77	4·78	13	78·53	4·07	47	—26·76	6·28	4·26**
d_1	48·44	4·02	16	70·36	3·24	74	—21·93	3·24	4·25**
d_2	45·50	4·85	20	64·94	3·17	66	—19·44	6·36	3·06**
Average	46·81	3·20	36	67·81	2·28	140	—21·00	2·28	5·35**

NOTE—Indicates significance at 5 per cent level.

** At 1 per cent level.

In the first period there was more flowering in wilted than the healthy plants. The difference was significant at 5 per cent level of significance. Out of eight treatments, significant differences were shown by 4 treatments of D_2, S_1, S_3, and d_1. In the case D_2 and S_1 treatments the differences were in favour of healthy plants while in treatments S_3 and d_1 these were in favour of wilted plants. In the second period healthy plants produced significantly larger number of flowers than wilted plants. This difference was significant at 1 per cent level of significance. Besides the four treatments of D_2, S_1, S_3 and d_1, the one other treatment which showed significant difference was d_2. But in all these treatments, the healthy plants had very high flower production over the wilted ones.

Incidence of early wilt and late wilt

About ten days after germination the symptoms of the disease in the field were first noticed. Characteristic drooping of leaves followed by their pronounced wilting, and drying and the necrosis of the tissues in the collar and main roots were the symptoms observed. On pulling out the seedlings it was noticed that they gave way at the collar or a little below it, so that a considerable part of the root system was always left in the soil [Narasimhan, 1929]. During the early stages the disease occurred in patches. The wilted plants were counted from the five rows once between 22nd and 24th December and again on 16th January. The percentage incidence was calculated on the initial stand.

The late wilt was first noticed on the 6th March. By 14th March the disease had appeared over a considerable area in the experimental plots. The outbreak followed a good shower of rain. The affected plants drooped, the top shoots folding up. Healthy and vigorous plants were generally observed to be more susceptible to the disease. The infection spread over the field within a short time.

The data on the incidence of early and late wilt are given in Table X. Generally the incidence of wilt, taken together for early wilt and late wilt decreased as sowing was delayed. But these differences amongst the three dates of sowing were not significant. Similarly with wider spacing than 10 inches the wilt incidence decreased, the differences being not significant. Significant difference due to incidence of late wilt was noticed between shallow seeding and deep seeding of gram. In shallow seeding the total percentage of incidence was low.

Wingard [1941] reviewing the ' nature of disease resistance in plants ' has quoted several authorities to support the contention " that as a rule the vigour of the parasite is directly proportional to the vigour of the plant ". The observations on growth in length, initial potential of growth and flower production indicate that the wilt susceptible plants, in general, were more vigorous than the healthy plants.

TABLE X

Incidence of early wilt and late wilt

Treatments	Actual percentage incidence of early wilt	Transformed values of p for early wilt	Actual percentage of late wilt	Transformed values of p for late wilt
Dates of sowing				
D_1—Oct. 27	3·6	6·45	10·31	17·01
D_2—Nov. 10	4·7	10·58	7·64	13·73
D_3—Nov. 24	2·1	5·13	5·62	10·10
'F' test		Not Sig.		Not Sig.
SEm		±3·18		±3·75
Spacings between rows				
S_1—10 inches	5·2	9·18	9·12	14·36
S_2—15 inches	2·2	5·31	7·03	12·58
S_3—20 inches	3·0	7·66	7·42	13·90
'F' test		Not Sig.		Not Sig
SEm		±2·50		±3·07
Depth of seeding				
d_1—2½ inches	3·4	7·02	5·35	11·78
d_2—5 inches	4·0	7·75	10·36	15.45
'F' test		Not Sig.		Sig.
SEm		±1·04		±1·14
C. D. 5 per cent		..	..	3·09
		—	—	$d_2 > d_1$

SUMMARY

A cultural experiment to study the effect of dates of sowing, spacing between rows of the crop and the depth of seeding was conducted to record observations on germination, stand of the crop, vigour of growth, flower production and incidence of wilt (*Fusarium orthoceras var. Ciceri*). The conclusions are as follows :

The germination of the crop was delayed, but the stand improved by delayed sowings. Both the cumulative growth in length and initial rapidity of growth were greater in the early sown crop. The ratio of flower production between October 27 and November 10 and between October 27 and November 24 were 1 : 0·66 and 1 : 0·46 respectively.

The differences in the number of plants per plot were significant and in favour of close spacing. The differences in the cumulative growth in length were small amongst the three spacings. The total flower production per plant increased with the increase in the spacing between the rows of the crop.

Deep sown seed germinated significantly more than shallow sown one. The plants from shallow sown seed had greater flower production than the deep sown crop.

Early wilt occurred about 10 to 15 days after sowing of the crop. Late wilt was observed from the 14th March. The effect of treatments did not show significant differences in the early wilt. Susceptibility due to late wilt was significantly higher by deep seeding of gram in the soil. Late wilt susceptible plants had higher initial potential of growth and larger flower production per plant. The healthy plants, however, tended to make up these differences partially by higher relative growth rate and greater flower production later on.

Acknowledgments

The authors are grateful to Dr T. J. Mirchandani, Head of the Division of Agronomy, for providing facilities to undertake this investigation, to Dr. R. S. Vesudeva, Head of the Division of Mycology, for arranging examination of wilt samples and Shri K. F. Kheswalla for actual identification of diseased material.

REFERENCES

Dastur, J .F. (1931). *Ann. Rept. Myc. Sec., Deptt. Agric., C. P. and Berar,* 1929-30

—— (1934). *Ibid.,* 1933-34

—— (1935). Gram wilt in C. P., *Agric. and Livestock,* **5**(*4*)

Howard, A., Howard, G. L. C. and Khan, A.R. (1915). Some varieties of Indian gram. *Mem. Dept., Agric. Bot. Series,* 7(*6*)

Narasimhan, R. (1929). A preliminary note on *Fusarium* parasite on Bengal gram. *Madras Deptt. of Agric. Year book,* 1928

Padwick, G. W. (1940). The Genus *Fusarium,* III. *Indian J. Agric. Sci.* **10**(*3*)

—— and Bhagawagar, P. R. (1943). Wilt of gram in relation to date of sowing *Indian J. Agric. Sci.* **13**(*3*)

Parr, C. H. (1943). Report. Imp. Agric. *Ann. Report, I.A.R.I.,* 1942-43

—— (1944). *Ibid.,* 1943-44

Rhind, D. (1925). *Ann. Rept. Myc. Sec. Deptt. Agric. Burma,* 1924-25

Wingard, S. A. (1941). The Nature of disease resistance in plants, I. *Bot. Review,* **1** (*2*), 59-109

SPACING EXPERIMENT WITH MAIZE IN UTTAR PRADESH

By P.S. Bhatnagar and G. Verma, Government Research Farm,

Kallanpur, Kanpur

[Received for publication on June, 22, 1955
Accepted for publication on September 9, 1956]

THE problem of stand, that is of population and row distance, appears to be an important factor in productivity of maize (*Zea mays* L.) or for that matter any other crop.

In Uttar Pradesh, the usual practice of the farmer who grows the maize crop is either to broadcast the seed in the field, or to sow behind the plough in furrows roughly about one and a half to two feet apart. It is common knowledge that the practice of broadcasting the seed results in a haphazard and uneven distribution of plants over the field. Where the plants become overcrowded, they are unable to draw optimum water and nourishment from the soil resulting in smaller size of cobs and greater percentage of nubbins. At places large patches having no plants may appear which encourage the growth of weeds. Another great disadvantage of the broadcast method of sowing is that it rules out the possibility of intercultivation of the field by bullock power. There is thus poor soil aeration and luxuriant growth of weeds. Weeding cannot be done, except by manual labour which besides being expensive and time consuming, is not always possible. Earthing up cannot be done in broadcast-sown fields, hence there is considerable lodging. All these factors greatly lower the yield of maize grain.

Maize is a row crop and lacks the ability to correct a thin stand by tillering, as wheat, barley, paddy, etc. do. It is, therefore, advisable to sow maize in rows by drilling.

In America maize is sown in hills which are spaced three or three and a half feet apart either way, and two or more plants are grouped together in each hill (checked planting), in order to increase the plant population per acre and at the same time permitting cross cultivation.

It was the object of this study to test the efficacy of different methods and rates of planting being practised in India and abroad under conditions in Uttar Pradesh. Hence an experiment was designed to compare the grain yield of maize in single plant hills and in multiple plant-hills (as in U.S.A.), with varying row to row and hill to hill distance, against broadcasting, at the same plant population per acre, with a view to determine the optimum distances and rates of planting maize under Kanpur conditions.

Review of the work

Marrow and Gardner [1893] reported that field corn in central Illinois produced smaller ears and stalks and more *stover* when planted thickly. They found no difference in yield between corn planted in checked rows and that planted in drilled rows when the same number of kernels were planted per acre.

Roberts and Kinney [1912] (quoted by Stringfield and Thatcher) experimenting with open pollinated corn at varying rates, both hilled and drilled under varying conditions, reached the conclusion that on a rich soil, in a normal season, thick planting would give the highest yield. On the contrary, thin planting is advantageous on poor lands and in dry season. Large varieties were not found to be as well adapted to thick planting as the small varieties. Planting with more than 3 stalks to the hill, made the plants lodge heavily and the quality of the grain was not found to be as good. On the basis of a number of years data, they suggested that on a good corn land of fair fertility, 3 stalks per hill or the equivalent in drilled corn will give the best results.

Mooers [1920] after extensive testing of southern open-pollinated varieties under varying conditions of soil and season, established a formula for estimating optimum stands. Variables in the formula are the estimated grain yield for the field, and a factor which varies with the productivity of the field. The latter is the weight of grain per plant, which was indicated by the experiments to accompany an optimum stand at a given acre grain yield.

Magruder [1928] stated that proper distance of planting depends upon such factor as size of plant, soil fertility, supply of moisture and the purpose for which the crop is grown.

Kiesselbach, *et al.* [1928] after comparisons extending over 12 years, concluded that an average of $2\frac{1}{2}$ to 3 plants in check rowed hills 42 in. apart, or the equivalent in drilled rows, was most practical for standard open-pollinated varieties in eastern Nebraska.

Richey [1933] has summarised the results of many experiments in the South and in the corn belt of the U.S.A. published prior to 1933. These experiments led to the conclusions that the optimum stand for corn is heavier as one proceeds from larger to smaller size of plants of the varieties of corn from the south to northwards, from low to high moisture supply, and from low to high soil fertility.

Watson [1937] and Watson and Davies [1938] have shown that close spacing in case of sweet corn increased the yield of both ears and forage in drilled row planting as the plants were thinned to one per place and concluded that the optimum area per plant is three square feet.

Bryan *et al.*, [1940] concluded that no consistent and material advantage will result from spacings closer than normally used (42 in. $\times$ 42 in.) and that within the comparisons involving the same number of plants per acre, minor variations in spacings had little effect on acre yields.

Innes [1941] working in Jamaica with open pollinated corn, obtained acre grain yields of 32·0, 40·0 and 43·0 bushels from planting rates which gave final stands corresponding to 2·43, 3·07 and 4·07 plants per hill at 42 inches spacing. With increasing rates of planting he found no difference in plant height, or in the percentage of plants destroyed by smut infection, a decrease in the ratio of plants to seeds planted, in the incidence of plants with two or more ears and in the weight of grain per plant.

Kinney [1943] (quoted by Dungan) reported that the world's highest official 10-acre yield record of 191·64 bushels per acre was obtained from drilling the kernels 10 inches apart in rows 28 inches apart.

Dungan Stringfield and Thatcher mention that originally row distances for maize were determined by the length of the yoke or by the thickness of an ox. This means that the convenience of working or the available tools rather than the weight of the yield dictated spacing.

Dungan [1946] concluded that on the more productive soils, the tendency of the farmers to narrow the rows and drill the corn is a move in the right direction for maximum yields. He observed that the most severe drawback to this practice is the somewhat greater amount of lodging associated with it.

Recently Brooks [1953] has concluded that under conditions of high fertility, optimum moisture, or other favourable growing conditions, it is necessary to grow a sufficient number of plants per acre in order to get the most from such conditions. On soils which are relatively low in fertility or in which moisture is to become scarce sometime during the season, it would probably desirable to plant at lower rates, at least if it is for grain production. For silage production, there is less danger of reducing yield by planting too thickly.

Such spacing studies have rarely been reported from India. Subbiah [1901] working on the cultivation of maize under Uttar Pradesh conditions observed that the outturn of grain fell more and more in proportion to the crowding of plants, and if this single point be properly attended to, the outturn of maize grain can be increased by 25 to 50 per cent. He recommended not less than one and a half square feet for the ordinary orange coloured varieties and not less than two square feet for the larger light yellow coloured ones. These findings of Subbiah, however, were not very critical as the experiment were not conducted under replicated trials.

Material and Methods

The experiment extended over a period of three consecutive years—1950 to 1952.

Soil. The experiments were conducted at the Government Research Farm, Kalianpur (Kanpur). The light loam soil was of average fertility and was given no fertiliser treatment except such as was needed to maintain the fertility at a moderate level.

Planting and cultivation. The sowings in all the years were done after the break of monsoon, in accordance with the local practice followed by the farmers. The method of sowing adopted was dibbling by hand. The plots were seeded at twice the indicated rate per hill (or hole). When the plants were four to six inches high the plantings were thinned to the correct rates per hill by removing the extra plants.

No extra fertilizer was added except the basal dose of about 100-125 maund of farmyard manure. The cultivation given was two ploughings or hoeings by cultivator between the rows and blocks and the plants were later earthed up along the rows when they were two to two-and-a-half feet tall to prevent them from lodging, except in the case of treatment No. six (Broadcasting) in which two hand weedings only were given.

Variety. The variety used in all the experiments was the medium, bold, late maturing, open-pollinated mass-selected variety Type 41 (a selection from Jaunpur).

Design of the experiment. The crop under the experiment was first sown in July 1950, using six randomised blocks of six plots. Due to incessant and heavy rainfall immediately after sowing, the field got waterlogged which adversely affected the germination, growth and vigour of the plants and ultimately the final stand at harvest. Two of the six blocks which gave very low yield due to very high mortality and subnormal vigour of plants, were eliminated from the analysis of variance.

Since the treatment and number of replications were equal, the design of the experiment was improved to latin square (6×6) in 1951 and 1952, thus removing two-way soil heterogenity and securing a more precise estimate of the error.

Treatments. The following treatments were compared ; the number of plants in each treatment being 90 plants per plot.

2 ft. $\times$ 1 ft. (area per hill 2 sq. ft.)—30 hills (one foot apart) in each of the three rows (two feet apart) with one plant in each hill or hole.

2 ft. $\times$ 2 ft. (area per hill 4 sq. ft.)—15 hills (two feet apart) in each of the three rows (two feet apart) with two plants in each hill.

3 ft. $\times$ 1 ft. (area per hill 3 sq. ft.)—30 hills (one foot apart) with two plants in each hill in the first row and with one plant in each hill in the second row.

3 ft. $\times$ 2 ft. (area per hill 6 sq. ft)—15 hills (two feet apart) in each of the two rows with three plants in each hill.

3 ft. $\times$ 3 ft. (area per hill 9 sq. ft.)—10 hills (three feet apart) in each of the two rows, with four plants in each hill in the first row and five plants in each hill in the second row.

Control. Broadcast sowing with 90 plants in each plot [6 ft. $\times$ 30 ft.].

Harvesting. All the plots of the experiment were harvested at identical stage of maturity, the same day whenever possible. As there are no facilities for determining the moisture content of kernels, weights were taken only after thorough sun drying of the cobs. This method of drying the material does not ensure that all the seed has been reduced to a uniform moisture content. Therefore, a number of sun dryings had to be given after shelling the seed. Weights were recorded when they became constant.

RESULTS AND DISCUSSION

The average stand, unadjusted and adjusted yields, standard errors of different treatments during the three years, 1950, 1951 and 1952, are summarised in Table I.

TABLE I

Average stand per plot and average yield (unadjusted as well as adjusted for stand in lb.) per acre for different treatments during 1950, 1951 and 1952

Design of experiment	Four randomised blocks			6 × 6 Latin square			6 × 6 Latin square		
	1950			1951			1952		
Treatments	Average stand per plot	Average yield (lb. per acre)		Average stand per plot	Average yield (lb. per acre)		Average stand per plot	Average yield (lb. per acre)	
		Unadjusted	Adjusted		Unadjusted	Adjusted		Unadjusted	Adjusted
2ft. × 1ft.	58	926	711	61	1310	1306	78	2208	1903
2ft. × 2ft.	44	778	710	69	1412	1331	78	1684	1841
3ft. × 1ft.	49	428	710	62	1210	1309	71	2057	1783
3ft. × 2ft.	42	762	710	63	1310	1311	83	2208	2005
3ft. × 3ft.	44	505	710	59	1114	1299	86	1755	2052
Broadcast	60	863	711	90	1593	1382	87	1755	2083
S.E.	8·8	216	182	2·7	56·5	79·3	2·0	153·7	189·2
F. test	Not significant	Not significant	Not significant	Significant	Significant	Not significant	Significant	Not significant	Not significant

A perusal of the results reveals that the final stand of the crop at harvest in all the treatments varied considerably instead of remaining constant at 90. It is also clear that the stand in broadcasting treatment was in general better than the rest of the treatments. The only reason for this disparity of stand is that all the treatments except broadcasting were given two intercultures and a final earthing up by bullock power with the result that a few plants were either damaged or broken inadvertantly during these operations. The treatment broadcasting could not possibly be given intercultivation except by hand. Consequently no damage to

plants occurred during the two hand weedings given to this treatment. This is also the usual practice with all the progressive cultivators. This necessitated the adjustment of yield for stand as also the analysis of covariance, otherwise the whole purpose of the experiment would have been defeated.

Results of 1950. The yields in the first year of the trial were very poor, on account of unavoidable delay in sowing and poor germination on account of heavy rains and consequent waterlogging in the field. Two of the six blocks got completely waterlogged, resulting in very poor and stunted growth of plants. They were, therefore, left out at the time of analysis of variance. The results indicated that the yields due to various treatments did not differ significantly from one another. However, the treatment 2 ft.$\times$1 ft. recorded numerically the highest yield followed by broadcasting, though the stand in latter was slightly better than the former. 3 ft.$\times$1 ft. spacing yielded the least of all. The regression coefficient was + 0·0611 lb./plot.

Results of 1951. The analysis of variance of yield data of second year trial revealed that the differences between various treatments were significant and that the broadcasting treatment yielded significantly higher than all the rest of the treatments. This was not at all unexpected because the desired stand of 90 plants was obtainable only in the broadcasting treatment and in all other treatments the stand was less than 90. The analysis also revealed that the differences in plant number were highly significant, suggesting thereby that part of the variation in yield of various treatments may be explained as due to variation in number of plants at harvest. Hence it was considered imperative to apply analysis of covariance between grain yield and the number of plants at harvset. The significance of treatments disappeared when account was taken of variations in plant numbers. The regression coefficient being +0·0125 lb./plant.

Results of 1952. The analysis of variance for yield of grain in the third year [1952] of the experiment showed that the various treatments did not differ significantly from each other. However, two by one and three by two treatments yielded numerically highest, though the stand in two by one treatment was lower than three by two and many other treatments varied in different treatments.

Since the desired stand of 90 plants was not obtained in the treatments, analysis of covariance was attempted here also. It was observed that even after adjusting the yield for stand, the differences between the treatments, though relatively large, could not be regarded as significant. The regression coefficient was found to be + 0·766 lb./plant.

A combined analysis of two years' data [1951 and 1952] was also carried out to separate the seasonal effects of the two years. The absence of significant difference between the yields from the different treatments experimented upon may be due to the high standard error caused by the considerable variation in the number of plants per plot. To determine whether the treatments are significantly different when the mean yields are adjusted on a basis equalising the number of plants per

plot, analysis of covariance was applied. The best estimate of coefficient of regression is calculated to be 0·03498 pounds per plant, the significance of which was not established by the data. Therefore, it is considered idle to analyse the reduced variance to adjust the yield data for variation in plant number. There is no increase in the accuracy of statistical estimation either, when the comparison is made with effective residual square (1·445).

The above results have revealed that there is no significant difference in yield of maize grain between the various methods experimented upon. However, one thing that strikes is that though the stand of 2×1 treatment has never been the best, yet this treatment gave higher yields than other treatments with comparatively better stand. It indicates that besides the population (total number of plants per acre), there is also an equally important factor of distribution (optimum area per plant) which governs the yield of maize. This optimum area per plant appears to be about two square feet in case of ordinary open-pollinated, medium and bold varieties of maize. Wider area than two square feet per plant may not give enough number of plants per acre for giving maximum yield.

What actually is the optimum number of plants and the optimum area per plant is being worked out by further experimentation at Kalianpur.

The conclusions arrived at are in conformity with those of Bryan *et al.* that within the comparisons involving the same number of plants per acre, minor variations in spacing or method of grouping plants in hills [as is done in U.S.A.] have little effect on acre yield of grain in case of maize in U.P. Other things being same the total number of normal plants [population] as well as area per plant [distribution] appear to matter most so far as grain yield is concerned.

Summary

The results reported herein are based on an experiment conducted during three consecutive years 1950, 1951 and 1952 at the Government Research Farm, Kalianpur, Kanpur. The experiment was designed to compare the grain yield of maize in single-plant hills and in multiple-plant hills with varying row to row and hill to hill distance (as in U.S.A.) against the local practice of broadcasting the seed, at the same plant population per acre (90 plants per plot) to study the efficacy of different methods of planting being practised in India and abroad, under Uttar Pradesh conditions.

The authors suggest that there is no one particular rate of planting which is applicable for every region where maize is grown, and this problem is a local one and should be determined in each tract separately.

The conclusions arrived at are in conformity with those of Bryan *et al.* [1940] that within the comparisons involving the same number of plants per acre, minor variations in spacing or method of grouping plants have little effect on acre yield of grain in case of maize in U.P.

The total number of normal plants per acre (population), as well as the area per plant (distribution) appear to matter most with regard to the grain yield of maize.

ACKNOWLEDGMENTS

The above work forms a part of the programme of research on the Scheme "The improvement of maize in U.P." financed by the Indian Council of Agricultural Research and the State Government on a 50 : 50 basis. The authors are grateful to Dr T. R. Mehta for kindly reading through the manuscript and making helpful suggestions and to Shri S. P. Mishra, Statistical Assistant in the Section of Economic Botanist (Oilseeds), for the help rendered in statistical analysis and interpretation of results. The authors also thank Shri Virendra Chandra (former Botanical Assistant) who collected most of the data during the first year.

REFERENCE

Annual reports of the Scheme for the improvement of maize in U. P. for 1950, 1951 and 1952

Brooks, S. N. (**1953**). Plant corn thick on fertile irrigated soils. *Crops and Soils*, **6** (1) : 15

Bryan A.A., Eckhardt R.C. (**1940**). Spacing experiments with corn, *J. Amer. Soc. Agron.* and Sprague, G.F., **27**, 707-714

George. H. Dungan (**1946**). Distribution of corn plants in the field. *J. Amer. Soc. Agron.* **28**, 310-324

Huelsen W.A. (**1942**). Yield of sweet corn in relation to distance and rate of planting. Univ. of Illinois *Agric. Expt. Sta. Bull.*, 487

Innes, R.F. (**1941**). The spacing of maize in Jamaica "red dirt" (Terra Rossa soils). *J. Jamaica Agric. Soc.*, **45** : 130-137

Kiesselbach *et al.* (**1928**). Tillage practices in relation to corn production. *Neb. Agric. Exp. Sta. Bull.* 232-10-11

Kinney, Paul M. (**1943**). (quoted by Dungan 1946) How to grow 192 bushels of corn. *Breeders' Gazette* 108-8

Mooers, C.A. (**1920**). Planting rates and spacing for corn under southern conditions—*J. Amer. Soc. Agron.* **12** : 1-22

Richey, F. D. (**1933**). Corn culture, *U.S.D.A. Farmers bull.* **1714** : 18-20

Subbiah, P. V. (**1901**). The cultivation of maize at the Kanpur Experiment Station. *Department of Land Records and Agri. U. P. Bull.* No. **16**

GENERAL CHARACTERISTICS OF INDIAN BLACK SOILS

BLACK SOIL OF THE TINNES TRACT

By P. K. R. Menon and M. P. Sankaranarayanan, Agricultural Research Institute, Coimbatore

[Received for publication on May, 17, 1955
Accepted for publication on August, 7, 1956]

THE Tinnes Tract comprises parts of the districts of Tirunelveli, Madurai and Ramanthapuram. The tract receives a limited rainfall and the crops are cultivated mainly under rain-fed conditions. There are two main types of soil occurring side by side in many places in the tract; these are the deep black soil and the shallow red soil. The soils are formed under the same climatic conditions from two different types of rock although several investigators hold the view that the same kind of rock is responsible for both types of soil. The black soil occurs in nearly 275,000 acres in the three districts. It is more fertile than the red soil. Shant and Marbut [1923] regarded the tropical black soils as being analogous to the tshernosem group of the temperature climates. Marchand [1924], however, is of the opinion that all tropical black soils are not of the same class. Theron and Neikerk [1934] think that the " black turfs are undoubtedly soils belonging to the same family as Russian chernozems ".

The farmers of the Tinnes Tract follow a four course crop rotation; cholam (*Irungu*)—cotton—cambu—cotton; cholam for fodder, cambu for food and cotton for cash. It has been widely noted in the tract that cotton following cholam is stunted in growth, is late to fruit and is poorer in yield (about 16 per cent) than when it follows cambu. The depressing effect of cholam on the succeeding crop has been called " the cholam effect". "The cholam effect" has been noted in other places and on crops other than cotton. For instance, it has been found in Coimbatore, Salem and South Arcot in Madras, in parts of Bombay and in the United States of America on several crops including wheat.

Various theories have been advanced to explain the " cholam effect ". But none of them is entirely satisfactory. After trying to correlate the " cholam effect " at Koilpatti with one or all of the hypothesis and failing to do so V. R. Iyer and S. Sundaram [1941] suggested that it might be due to an increase in the replaceable sodium content of the soil presumably drawn up from the lower layers of the profile during the growing period of the cholam crop. This suggestion has not found favour for two reasons; (i) the " cholam effect " is noted for only one season after cholam

while the effect of sodium in the soil complex would persist for several seasons : (ii) the black soils of the tract have a very high lime status with plenty of free calcium carbonate and it is difficult to understand how sodium can, within one season, get a stranglehold on the soil. It is also difficult to understand how the shallow-rooted cholam can bring up large quantities of sodium from the deeper layers of the soil. Direct estimation of exchangeable sodium and of free sodium salts in the soil before and after the growth of cholam did not show any increase over the very small quantity originally present.

Therefore, to elucidate the " cholam effect " a comprehensive rotation experiment with sixteen treatments (with cholam before and after cotton, cambu before and after cotton and these rotations with and without legumes such as black gram and indigo) and four replications for each treatment was laid out at the Agricultural Research Station, Koilpatti in 1950-51. Soil samples were drawn from these treatments before sowing and after the harvest of the crops and the properties of the soils were studied. The experiments were stopped before sufficient data could be collected to explain the "cholam effect" ; but a considerable amount of data on the properties of the black soil has accumulated and these are presented in these papers.

The probable cause of the " cholam effect " may be sought in the cholam stubbles that remain in the field after the harvest of the crop. These are rich in carbohydrates and have a wide C/N ratio. Immediately after the harvest of the cholam crop there is not sufficient moisture in the soil for the micro-organisms to bring about their decomposition. However, when next the cotton crop is grown in rotation, after the rains, the micro-organisms start the decomposition of the cholam stubbles and multiply enormously. The stubbles being rich in carbohydrates and poor in nitrogen, the micro-organisms utilize the nitrates and other available nitrogen present in the soil for their own biological activity and lock them up as microbial protein. There is, thus, a temporary dearth of available nitrogen in the soil. When this coincides with the active growing period of cotton, the plants do not get sufficient amount of this important nutrient and become stunted in growth. The stunted growth is correlated to the final decreased yield of the crop. But the locking up and dearth of nitrogen in the soil is only a temporary phase. When the micro-organisms die the nitrogen held up in their tissues is released becoming available and the soil reverts to its normal fertility. This accounts for the harmful effect of cholam being temporary and confined to only one season. Additional evidence in support of this theory is obtained from the action of a legume like indigo grown in association with *Irungu* cholam. After the mixed crop (of cholam and indigo) cotton rotated with cholam is not adversely affected. Evidently the higher amount of nitrogen resulting from the associated growth of cholam and indigo makes up the deficiency of nitrogen in the active growing period of the succeeding cotton crop.

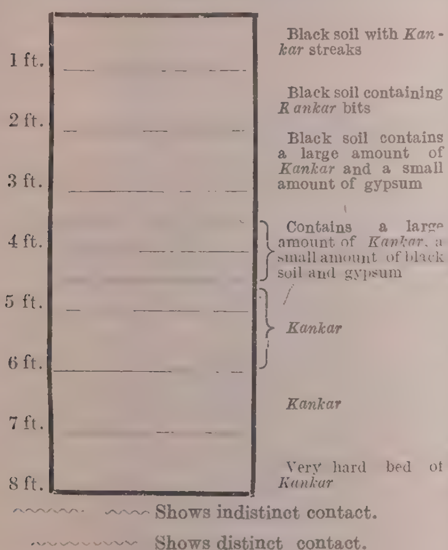
It is found that this hypothesis as to the cause of the harmful effect of cholam on the succeeding cotton crop is substantiated by subsequent work carried out in the Agricultural Research Station, Koilpatti. In one set of experiments cholam stubbles were removed after the harvest of the crop and cotton raised subsequently.

In this, cotton gave normal yield and no adverse effect due to cholam was noted while in an adjacent plot where the cholam stubbles were not removed the harmful effect was recorded on cotton. This is a direct evidence in support of the theory.

Again, it has been found that " the cholam effect " can be nullified by giving nitrogenous (and phosphatic) manures to the cotton after cholam, so it is as a result of the depletion of the available soil nitrogen by the micro-organisms (decomposing the stubbles) during the active growing period of the cotton that the crop suffers.

Material and Methods

Before the properties are discussed it would be of advantage to study the profile characteristics of the soil. The black soil of the Tinnes tract is deep and heavy. The rocks from which the soil has developed are granites and gneisses, often garneteferrous. The soil of the Agricultural Research Station, Koilpatti, may be taken as typical of the tract. The profile characteristics are given below.



The first and second feet of soil are black in colour with plenty of *kankar* streaks. In the lower depths *kankar* is found in abundance and is sometimes associated with small amounts of gypsum. Below four feet considerable amounts of *kankar* are found with small infiltrations of black soil. At greater depths there is practically no soil and the material is mainly *kankar*. The R_2O_3/RO ratio of the first and second foot of the soil is about 4·5 and is lower in the lower layers of the profile. In the 6th foot it is only 1·9 indicating a decrease in the sesquioxides and a simultaneous increase of calcium and magnesium. The SiO_2/R_2O_3 and SiO_2/Al_2O_3 ratios of the surface soil are 3·5 and 4·5 respectively and these increase with depth consequent on a decrease in sesquioxides.

Properties of the black soil

For the study of the properties the samples of the soil were drawn in four depths, 6 in., 6-12 in., 12-24 in. and 24-36 in. The samples were cut out from the vertical sides of profile pits, mixed thoroughly and 4 to 5 lb. of the soil was dried in the shade and brought to Coimbatore for analysis. In the laboratory the samples were gently pounded with a wooden mallet and passed through a sieve with 2-mm. round holes. The materials retained by the sieve were taken as stones and gravel and their percentage to the whole soil calculated. The finer material that passed through the sieve was taken up for analysis.

A duplicate set of samples dried in the shade was analysed for crumb structure at Koilpatti.

The following properties of the soil were studied:

The mechanical composition

The base exchange properties—

(*a*) Base exchange capacity
(*b*) Exchangeable calcium, magnesium, sodium and potassium
(*c*) The degree of alkalinisation

Nitrogen content
Organic carbon
Water soluble salts
*p*H
Apparent and absolute specific gravity
Water holding capacity
Volume expansion
Capillarity
Crumb structure

In this article the mechanical composition and the base exchange properties of the soil are considered.

The mechanical composition of black soil

The mechanical analysis of the soil has been carried out by the International Method using Robinson's pipette. In the method the soil passing through the 2 mm. sieve is fractionated into clay, silt, fine sand and coarse sand with effective diameters 0·002 mm. and less, 0·02 to 0·002 mm., 0·2 to 0·02 mm. and 2 to 0·2 mm. respectively. As the soils are poor in organic matter (organic carbon about 0·25 per cent) treatment with hydrogen peroxide has been dispensed with. The soils contain a good amount of calcium carbonate which increases with depth. The cementing action of carbonates and of iron and aluminium compounds is destroyed with N/5 hydrochloric acid. The acid is added in small quantities to 20 gm. of the air-dry soil until brisk effervescence ceases and then 200 cc. more is added, stirred occasionally and left overnight. The soil treated in this manner is taken up for mechanical analysis. The average results of two sets of samples are given below.

Results of mechanical analysis (dry basis)

—	0-6 in.	6-12 in.	12-24 in.	24-36 in.	0-6 in.	6-12 in.	12-24 in.	24-36 in.
Clay per cent	55·52	57·23	54·03	56·31	56·02	62·01	65·34	65·94
Silt per cent	12·27	11·51	15·47	14·79	10·29	10·89	10·59	12·43
Fine sand per cent	14·81	14·39	11·90	10·13	15·56	13·12	12·08	11·15
Coarse sand per cent	13·87	12·81	10·76	8·98	13·67	10·81	8·02	6·75
Matter soluble in HCl (By diff.) per cent	3·53	6·11	7·80	9·79	4·45	3·16	3·97	4·47
TOTAL	100·00	100·00	100·00	100·00	100·00	100·00	100·00	100·00

The results given above reveal that the soil is a heavy clay in all the depths studied, the clay content being above 50 per cent and the finer fractions making up two-thirds to three-fourths of the soil. The finer fractions increase slightly with depth. It is also evident that there is a good amount of *kankar* or calcium carbonate in the surface soil and the lower layers, and that this constituent generally increases with depth. Beyond four feet *kankar* is the main constituent and there are only small infiltrations of the black soil.

Dehydration studies of the clay fraction indicate that the clay consists of the montmorillonite and bedilite types with a small proportion of kaolin. The clay has a high base exchange capacity and the soil is fertile. However, cultural operations in the soil have to be carried out with caution, otherwise the tilth will be destroyed. The internal drainage of the soil is fairly satisfactory as the high lime status of the soil together with the free calcium carbonate and gypsum make for fair downward movement of water.

Base exchange properties

The study of the base exchange properties of black soils is a problem by itself. Although there is not much of soluble salts in the surface soil and in the sub-soil, the salt content of the gypseous layer is 1 per cent and more. There is a considerable amount of free calcium carbonate and some quantity of gypsum in most horizons of the profile. There was no satisfactory method for the estimation of exchangeable bases in soils containing calcium carbonate and gypsum. So the authors had to devise a method and it has been published in the *Madras Agricultural Journal* [1953] Vol. XL. The method consists in : (1) the washing out of the soluble salts of the soil (not sulphates) with 40 per cent alcohol adjusted to pH 7·05 with ammonia ; (2) the elimination of gypsum as barium sulphate by the addition of excess of barium hydroxide or acetate solution and of the excess of barium as carbonate by bubbling carbon dioxide through the mixture and warming ; (3) leaching the treated soil with N/2 ammonium acetate adjusted to pH 7·05 ; (4) estimation of exchangeable magnesium, sodium and potassium in the leachate ; (5) estimation of the base exchange capacity of the leached soil ; and (6) obtaining exchangeable calcium by difference by subtracting the sum of exchangeable magnesium, sodium and potassium from the total exchange capacity. The method was used in studying the exchange properties of the black soils of Koilpatti and of similar black soils of Siruguppa and found to be entirely satisfactory.

There was also no satisfactory method in the laboratory for the direct estimation of exchangeable sodium in soils. So the senior author standardised a method using a 10 per cent solution of uranyl magnesium acetate as the reagent for quantitatively precipitating sodium. The method has been published in the Report of the First Scientific Officers' Conference, Madras Department of Agriculture [1951].

The results of analysis of two sets of Koilpatti soils for base exchange studies are given below for 100 gm. of soil.

Results of analysis of Koilpatti black soils for exchange properties

	0-6 in.	6-12 in.	12-24 in.	24-36 in.	0-6 in.	6-12 in.	12-24 in.	24-36 in.
Base exchange capacity m.e.	58·50	60·65	65·04	66·02	59·50	63·75	67·22	67·92
Exchangeable calcium m.e.	48·07	48·20	52·80	50·34	47·63	51·11	53·24	53·29
Exchangeable magnesium m.e.	9·33	11·96	12·22	11·96	9·41	10·52	12·14	12·95
Exchangeable potassium m.e.	1·37	0·90	0·78	0·72	1·35	1·25	0·97	0·78
Exchangeable sodium m.e.	0·26	0·36	0·33	0·53	1·10	0·87	0·86	1·09

From the results it is seen that the soils have a high base exchange capacity ranging from 58 to 68 milliequivalents per 100 gm. and that the base exchange capacity increases with depth. Calcium forms 80 per cent and more of the exchangeables bases while magnesium accounts for about 16 to 20 per cent. The monovalent cations, potassium and sodium are present only in very small quantities in the exchange complex, potassium to the extent of 1 per cent to 2 per cent and sodium to the extent of 0·5 to 2 per cent. The exchangeable calcium and magnesium of the soil increase slightly with depth. On the other hand the exchangeable potassium decreases with the depth of the soil. No correlation between depth and the sodium cation is apparent. The degree of alkalinisation of the surface soil is low being only 3 to 4 per cent and it does not show any increase up to the depth studied, namely 3 feet.

It is generally conceded that colloidal clay (inorganic and organic colloids) is the seat of the base exchange properties in soils and that the coarser particles with the exception of silt have very little exchange capacity. So if all the exchange capacity of the soil is attributed to clay it is found that each gram of clay contributes to more than one milliequivalent.

Summary

The black soils of the Tinnes Tract are heavy clays, the finer fractions forming two-thirds to three-fourths of the soil. They have high base exchange capacities of over 50 milliequivalents per 100 gm. of the soil and calcium forms 80 per cent and more of the exchange capacity.

A method for the estimation of exchangeable bases in a soil containing free calcium carbonate and soluble salts including gypsum is described in a previous publication.

Acknowledgment

The authors express their gratitude to the late P. D. Karunakar who was the Government Agricultural Chemist at the time these studies were started and to Shri T. Rajagopala Iyengar, the Government Agricultural Chemist In-charge for his sustained interest and encouragement. They also thank the Director of Agriculture, Madras, for allowing the publication of the article.

REFERENCES

Bal, D. V. (1935).—*Trans. Third Internai. Congr. Soil Sci.* **3,** 155

Shanty, S. L. and Marbat, C. F. (1923). *The Vegetation of Soils of Africa* : New York

Theron, J. J. and Niekirk, P. le R. Van (1934).—*S. Afri. J. Sci.* **31,** 320-46

Marchand, B. De, C. S. (1924).—*S. Afri. J. Sci.* **21,** 162-81

Viswanath, B. (1939).—*Ind. Soc. Soil Sci. Bull.* No. 2, 4-7

Ramanatha Iyer, V. and Sundaram, S. (1941).—*Indian J. Agric. Sci.* **37,** 52

Raychaudhuri, S. P. (1941).—*Indian J. Agric. Sci.* 100-109

Menon, P. K. R. and Sankaranarayanan, M.P. (1953).—*Mad. Agric. J.,* Vol. LX, February

——————— (1956), *Proceedings of the First Sci. Workers' Conference* held at A.C.R.I., Coimbatore p. 2-6.

Unpublished Soil Profile Register of the Government Agricultural Chemist, Coimbatore.

STUDIES ON THE VEGETATIVE PROPAGATION OF CASHEW (*ANACARDIUM OCCIDENTALE* LINN)

APPROACH GRAFTING (INARCHING) WITH AND WITHOUT THE AID OF PLASTIC FILM WRAPPERS

By V. N. Madhava Rao and I. K. Sambashiva Rao, Central Cashewnut Research Station (Kotekar P. O.), Mangalore

[Received for publication on September 22, 1956
Accepted for publication on October 25, 1956]

(With 2 Text Figures)

SEED propagation has been the rule with the cashew. In view of the obvious disadvantages associated with this method of multiplication, trials on vegetative propagation were initiated at the Central Cashewnut Research Station, Mangalore in 1953. Among these, air-layering by cincturing of shoots with the aid of Alkathene film wrappers proved so promising as to be worthy of adoption for large scale multiplication of planting material[4]. The other methods included grafting, besides budding and propagation by stem cuttings. In the earlier trials, inarching in the conventional manner was alone tried. Later on, following the favourable response to air-layering trials by employment of the plastic film wrapper, Alkathene, attempts were made to take advantages of this film in the inarching operations as well. A parallel series of trials in inarching was made using the Alkathene film as containers for the seedling root-stocks.

The results in this article report the progress of these two sets of trials in inarching.

Review of Literature

Trials conducted at Kodur [Andhra State[8]] showed that layering, side-grafting inarching, patch and shield budding were all possible but layering and inarching secured the best results. Naik[8] reported that a 100 per cent success was possible by layering and an almost equally high "take" by inarching. The success in layering was reported to be 40 per cent in a trial conducted in 1945 at Taliparamba[1]. The above data, however, seem to be the results of only preliminary studies.

Considering the fact that the cashew plant has generally been known to resent transplantation and rarely survives when lifted with naked roots, it is obvious that the normal method of lifting seedlings of graftable size from nursery beds for use as rootstocks is wasteful. The alternative is one of sowing seeds *in situ* in containers and the seedlings so raised used directly as rootstocks. The chief drawback of this method, however, is that the seedlings so raised are often lanky, lacking in sufficient size and vigour for grafting. Adoption of inarching in any appreciable scale in cashew propagation, therefore, demands for its success, a method by which

FIG. 1. Cashew seedling packed in alkathene film prior to their use for grafting

FIG. 2. Cashew grafts raised with root-stock placed in alkathene film

the transplanted seedlings establish and thrive. The inarching trials reported here were first made on seedlings grown in hill-grass containers but as stated above the attempts proved futile. A successful method for transplanting seedlings was devised subsequently ; this consisted of lifting the seedlings from seed beds followed by heading back the stems to a half or third of their length and then potting them. The seedlings transplanted thus put forth new shoots in the course of a month, after which they were utilised for grafting. This essentially preliminary step to the grafting operations is in itself a problem of which, barring the above trials at the Central Cashewnut Research Station, Mangalore[10], mention is made only by Tai and Topper[9] in Africa ; their results are more or less similar to those reported by Vazir Hassan and Madhava Rao[10]. Among other methods, Naik[8] has mentioned that side-grafting was distinctly promising though not to so great an extent as inarching and layering.

The use of plastic film wrappers in plant propagation has of late assumed considerable importance, particularly in air-layering of hardy fruit and other perennial plants due to its special property of inertness, durability and moisture-retaining capacity. This film is not only very effective in its results but reduces considerably the operational costs. Air-layering of cashew as a commercial proposition has been made possible by the aid of this film[4,5]. Trials by the authors with mango shows that propagation is possible both by air-layering and inarching using alkathene film. With Kalapadi variety of mango as much as 90 per cent success has been achieved in air-layering[3]. The average success in inarching was 50 per cent, the cost of production being as low as Re. 0/5/9 per graft against the rate of Re. 0/12/0 to Rs. 1/8/0 by the normal method[2,3]. Garg[7] has reported similar success both by air-layering and grafting with the mango.

Material and Methods

Eleven-month-old cashew seedlings which had attained the graftable size with a girth of about 4·5 cm. and height of 50 to 60 cm., were lifted, headed back to half their height, and transplanted to hill-grass containers, 10 in. long and 4 in. broad, containing equal mixtures of red earth, leaf mould, and rotten cattle manure. The transplanted seedlings were kept in the shade for about a month. When fresh sprouts emerged, the seedlings were used for grafting, i.e., when they were nearly a year old.

The actual process of inarching consisted of the slicing of a strip of bark with a part of the inner wood from two to three inches both from the scion shoot and the stem of the potted plants on the portions to be united, and tying the shoots together in that position with country twine. A strip of waxed cloth was wound over the twine. The separation of the graft was done in two or three stages depending upon the nature of the graft union. All through this period, the plant in the pot had to be regularly watered, the frequency depending upon the weather conditions. In the non-rainy period watering had to be done once daily and during the summer months (March to May) even twice. The inarching was, therefore, suspended only for the three months [December 1955, January 1956 and February 1956], the dry period of the year, as it was felt that the watering costs at this part of the year

would be prohibitive. Moreover, these grafts, not being immediately available for planting would have to be retained in the nursery, thereby adding further to the costs. The trials initiated in October 1954, were continued in November 1954 and resumed again in March 1955 and concluded in September 1955, i.e. over a nine-month period, in nut bearing trees in the neighbourhood of the Central Cashewnut Research Station, Ullal, Mangalore. Ten grafts were made in each month of operation.

Inarching with plastic film wrapper

The trials of this method were initiated in April 1955. The rootstock seedlings were transferred to grass containers as described already, after about 30 to 40 days, the grass covering was removed carefully. Around this, a 20 in. × 12 in. sheet of Alkathene film (100 gauge) was wrapped. The free ends of the film above and below were secured air-tight. The seedlings thus packed in Alkathene film were used for grafting on to scion shoots roughly of the same thickness as the seedling rootstocks in all possible situations and positions of the selected parent tree. The separation of the graft from the parent tree was effected in two or three stages.

A slight modification of the above method was also attempted to ensure further the availability of moisture to the seedling in the container. This consisted of wrapping the ball of earth with a piece of gunny before enclosing it in the Alkathene film. This reduced the chances of any rupture of the film by coarse and hard contents or by any other mechanical disturbance.

Ten shoots were worked per treatment per month commencing from April 1955. The trial concluded in March 1956. The grafts raised from April to September 1955 were not watered while those of the October to March batches were watered on two occasions in view of the prevailing dry weather. The percentage of success under each method and the cost of production were worked out.

Results

Inarching (Conventional method): Table I represents the results of inarching by the conventional method.

Table I

Cashew—Results of inarching (conventional method)

Month of operation	No. of grafts obtained out of 10	No. of days for separation	Remarks
October, 1954	6	95	
November, 1954	10	90	
March, 1955	8	90	

TABLE I (contd.)

Cashew—Results of inarching (conventional method)

Month of operation	No. of grafts obtained out of 10	No. of days for separation	Remarks
April, 1955	6	108	(Severe gale damaged some grafts)
May, 1955	3	101	
June, 1955	7	108	
July, 1955	7	90	
August, 1955	3	90	
September, 1955	3	86	
Mean :	6	95	

The above data show that the response of cashew to inarching on own seedling stock was generally except good in May and August-September under Ullal conditions. A certain amount of disturbance due to cattle grazing on the private plantation where the trials were conducted and a severe gale in May were responsible for a reduction in the outturn in April, May, August and September. No correlation is apparent between the climatic conditions and the success of the experiment.

The average cost of production worked out to ten annas per graft, the batch raised in June being the cheapest (Re. 0/5/9). The cost of production during the pre-monsoon period from March to May worked out to Re. 0/8/8 per graft.

Inarching with Alkathene film

Corresponding results in the inarching trial with rootstocks packed in Alkathene film are given in Table II.

TABLE II

Cashew—Results of inarching using Alkathene film

Month of operation	Total No. made	Rootstocks packed in		Total No. of grafts obtained	Percentage of success	No. of days for separation
		Gunny and Alkathene	Alkathene alone			
		No. successful				
April, 1955	20	4	4	8	40	94
May, 1955	20	6	6	12	60	102
June, 1955	20	4	6	10	50	109
July, 1955	20	1	3	4	20	110
August, 1955	20	2	4	6	30	109

TABLE II (contd.)

Cashew—Results of inarching using Alkathene film

Month of operation	Total No. made	Rootstocks packed in		Total No. of grafts obtained	Percentage of success	No. f days for separation
		Gunny and Alkathene	Alkathene alone			
		No. successful				
September, 1955	20	0	4	4	20	101
October, 1955	20	0	2	2	10	117
November, 1955	20	3	5	8	40	127
December, 1955	16	2	1	3	19	133
January, 1956	20	8	7	15	75	115
February, 1956	20	5	5	10	50	101
March, 1956	20	7	6	13	65	88
Mean :	..	3·5	4·4	7·9	39·9	108·8

It is apparent from the above results that although the success has not been uniform throughout the year, it is sufficiently encouraging during the few months preceding the monsoon season that commences in June. From January onwards

until June excepting April. the success has not been less than 50 per cent while it has been as high as 75 per cent in January. This facilitates the preparation of grafts in time for planting in June.

Observations on the activity in the parent trees during the several months showed that as in air-layering[4]. the maximum success in grafting has also been achieved when the growth, flowering and fruiting activities on the tree are in progress. The relatively low percentage of success is correlated with a period when the tree is dormant or just in the initial stages of its growth phase.

Considering the fact that under this method practically no watering is necessary to the graft on the plantation site, a success of 50 per cent may be considered high. The occurrence of the cyclone in 1955 which damaged the grafts prepared in April and May is also a fact to be taken into consideration in assessing the results recorded.

In the two methods of wrapping the rootstocks, there seems to be no special advantage in the extra protection with the gunny. The results favour the wrapping of the ball of earth without any gunny piece between it and the film. It is also seen that minimum of three months is necessary to separate a graft by this method ; in November and December, the period has been as long as 127 and 133 days respectively, with correspondingly poor results.

The cost of production of grafts worked out to Re. 0/6/7 by this method.

Of the several batches of grafts raised under the above trials, 18 were planted in June-September 1955, of which 16 survived. At the end of one year they have attained a mean h ight of 91·4 cm., with a stem girth of 11·9 cm., and spread of 94·9 cm., as compared to a mean height of 64·2 cm., stem girth of 5·6 cm., and a spread of 47·5 cm., of seedlings of a comparable age.

The growth and vigour in general appeared satisfactory.

Discussion

Inarching has been demonstrated as one of the possible methods of propagating the cashew by previous work at other centres[8]. Grafts of cashew, however, are likely to have little commercial advantage unless produced at a low cost. The wide disparity in the cost of making grafts and of the production of layers, the former at eight to ten annas and the layers at two to three annas, is a serious limiting factor in the extended use of grafts.

In view of the above fact the Alkathene plastic film claims special recognition. From the study reported in this paper this film has given sufficient evidence of the possibility of reducing the costs considerably, enabling the undertaking of the grafting operations in situations where watering the prepared grafts is a serious problem.

As in the case of layering the success in inarching seems to be related to the growth activity of the plant. The period between January and June when the plant exhibits the maximum growth, flowering and fruiting activities is congenial for satisfactory graft union also.

The performance of the grafts in the field during the period of observations of one year until now has been satisfactory and it is hoped that the orchard performance of the grafted trees will also be satisfactory.

The success with the use of the film during the summer months is a favourable feature, as it renders possible the production and planting of grafts in a continuous sequence without any prolonged nursery phase with its attendent losses of material and increase in maintenance.

A comprehensive experiment to study the comparative orchard performance of the progenies raised by layering and grafting is being undertaken at the Cashewnut Research Station ; this may bring further points of interest to light with regard to these clonal progenies.

Summary

Trials on inarching of cashew conducted at the Central Cashewnut Research Station, Mangalore, during 1954-1956 have been reviewed.

Inarching by the conventional method gave an average success of 60 per cent with the highest percentage in November.

The average cost of production worked out to ten annas for the entire period while it was roughly six annas during June.

Inarching trials using rootstocks packed in Alkathene gave encouraging results particularly during January-May when the success ranged from 40 to 75 per cent.

The cost of production worked out only to Re. 0/6/7 with grafts in which Alkathene film was used.

Acknowledgment

The authors are grateful to Shri U. Narasinga Rao, Horticulturist and Professor of Horticulture, Agricultural College and Research Institute, Coimbatore, under whose direction the work was carried out at the Central Cashewnut Research Station (Kotekar P. O.), Mangalore, a scheme partly financed by the Indian Council of Agricultural Research.

REFERENCES

1. Anon (1954). *Memoirs of the Department of Agriculture*, Madras. Superintendent, Government Press, Madras. pp. 648-654
2. Garg, M. L. (1954). Mango propagation by means of marcotting or air-layering. *Indian J. Hort.* Vol. XI No. 4
3. *Ibid* (1954). Mango grafting made easy and cheap. *Indian J. Hort.* Vol. XI No. 4
4. Madhava Rao, V. N. (1956). Studies on the vegetative propagation of cashew (*Anacardium occidentale* L.) 1. Air-layering by cincturing and etiolation of shoots. (In Press)
5. *Ibid* (1956). Multiply the better yielding cashewnut. *Indian Fmg.*, Vol. VI No. 3
6. Madhava Rao, V. N. and I. K. Sambashiva Rao (1956). *Propagation of mango by air-layering. S. Ind. Hort.* Vol. 4. No. 2
7. *Ibid* (1956). *Mango grafting with the aid of plastic film wrappers. S. Ind. Hort.* Vol. 4. No. 2
8. Naik, K. C. (1948). *South Indian Fruits and their culture.* P. Varadachary & Co., Madras
9. Tai, E. A. and B. F. Topper (1947). Transplanting cashew seedlings. *J. Jamaican Agric. Soc.* 51 : 116-118
10. Vazir Hassan, M. and V. N. Madhava Rao (1956). Studies on the transplantation of seedlings of cashew. (In Press). (*Indian J. Agric. Sci.*)

PRELIMINARY STUDIES ON THE FLORAL BIOLOGY OF CASHEW (*ANACARDIUM OCCIDENTALE* LINN)

By V. N. Madhava Rao and M. Vazir Hassan, Central Cashewnut Research Station, Mangalore

[Received for publication on September 19, 1955
Accepted for publication on June 29, 1956]

(With Plate I and one Text Figure)

THE cashewnut (*Anacardium occidentale* L.) belongs to the natural order Anacardiaceae. Unlike in mango which is another member of this natural order, no distinct varieties are known in cashew. The several types met with are broadly classified according to the nut size, 'apple' colour and other economic characters. Enormous variations in the performance of individual trees are noticed due to the influence of several factors, one of which is the inherent character of the floral parts. The material presented in this article refers to the preliminary studies on the flowering and floral characters of cashew conducted at the Cashewnut Research Station, Mangalore, from November, 1954 to June, 1955.

Review of Literature

Studies on the floral biology of cashew were conducted at the Fruit Research Station, Kodur (Andhra) and at the Agricultural Research Station, Taliparamba (Madras)[1], with particular reference to the percentage of flowers of each sex produced, the size of the flower, anthesis, stigma receptivity, proportion of bisexual flowers, etc. Controlled cross pollination has also been attempted. Morada[3], dealing with cashew culture in the Philippines has described the inflorescence giving details of the number of flower stalks and number of individual flowers in the panicles. He has also described the flower besides furnishing elaborate details to bring out the relative size and weight of the nut and kernel in relation to the apple. Apart from the above references there seems to be no other record on the floral biology of cashew. Studies on the growth features in relation to cropping behaviour in mango have been carried out in detail by Naik and Mohan Rao[2] at the Fruit Research Station, Kodur which include the study of the relationship between sex distribution in flowers and the bearing tendencies as also the difference between varieties in respect of such characters as length of style, stamen, distance between stigma and anther tip, etc. They found a definite positive correlation between the percentage of perfect flowers in the panicle and the number of fruits borne, which varied with each variety. Marked variations were also observed in the length of stamen and the distance between stigma and anther tip. The shorter style length and the lower ratio of style length to stamen length observed in certain varieties were helpful in securing a better set of fruits.

Material and Methods

Five adult, bearing trees located in different situations in neighbouring plantations were selected for the studies. Twenty dormant shoots from all around the trees were selected in each of the five trees and tagged on October 4, 1954. Observations on the progress of the tagged shoots were recorded with regard to the following features :

(i) *Growth :* The time of appearance of flush and season of growth.

(ii) *Growth extension :* The linear extension in centimeters made by the tagged shoots at monthly intervals.

(iii) *Leaf characters :* The number of leaves produced on the new leader shoots at monthly intervals ; the time taken for a new leaf to attain the green ripe stage.

(iv) *Flowering :* The period and intensity of flower production during the various months when the tree is in bloom.

(v) *Inflorescence :* The description of the panicles.

(vi) *Flowers :* The total number of flowers produced of each sex in each of the 100 tagged shoots and description of the floral parts.

(vii) *Anthesis :* The time of opening of male and hermaphrodite flowers.

(viii) *Receptivity of stigma :* Dusting pollen on the stigma at intervals of two hours and subsequent examination of the dusted stigmas stained with cotton blue stain for pollen tube formation.

(ix) *Anther dehiscence :* The time of anther dehiscence.

(x) *Pollen viability :* This was determined by staining the pollen with

(*a*) acetocarmine and glycerine mixture and

(*b*) cotton blue stain. The pollen collected from the flowers was stored and examined at intervals of 24 hours till signs of loss of viability were noticed.

(xi) *Fruit set :* The percentage of fruit set, the time taken for reaching various stages of maturity, the number of fruits ultimately carried to maturity and fruit set under natural and hand pollination.

(xii) *Insect visitors and pollination :* The insect visitors, the time of visit and the mode of pollination.

(xiii) *Effect of cloudy weather on blossoming :* Data on the effect of cloudy weather for four days were collected.

Results

1. *Growth*

There are mainly two active phases of growth, one commencing in October and lasting till January and another occurring between March and May.

2. *Growth extension*

Linear extension by a shoot during the active phase varies from tree to tree and within a tree. During the active phase commencing in October it varied from 2·5 to 21·5 cm. per shoot with a mean of 10·7 cm. and the extension growth ceased with the flowering of the shoots. The subsequent growth on these shoots during the beginning of March comprised only the lateral shoots arising from buds below the inflorescence.

3. *Leaf characters*

The number of leaves produced on new leader shoots is not uniform either within the tree or between trees and ranges from 3-14 with a mean of nine per shoot. The colour of the emerging leaf changes into pale green and then dark green, the change extending from the petiole towards the tip. On an average, a leaf reaches the green ripe stage in 20 days from the date of its appearance as a bud visible to the naked eye.

4. *Flowering*

Eighty-four out of 100 tagged shoots flowered between December, 1954 and February, 1955, while the rest failed to flower. The period of peak flowering and the number of days taken for complete flowering of all the tagged shoots in each of the five trees under observation is summarised in Table I.

TABLE I

Details of flowering in the selected trees

No. of shoots per tree (under observation) : 20

Tree No.	Date of earliest flowering	Date of flowering of the last tagged shoot	No. of days taken for complete flowering	Percentage of shoots that flowered during						Period during which maximum No. of shoots flowered
				December		January		February		
				1st F.N.	2nd F.N.	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.	
				F.N. Fortnight.						
1	1-12-54	17-12-54	17	95	5	..	..	..	..	1st F.N. of December
2	21-12-54	8-1-55	17	..	60	40	..	..	..	2nd F.N. of December
3	15-12-54	4-1-55	19	5	80	15	..	..	..	2nd F.N. of December
4	9-12-54	20-1-55	41	27	27	27	19	..	..	1st & 2nd F.N. of December & 1st F.N. of January.
5	3-12-54	8-2-55	65	63	31	..	..	..	6	1st F.N. of December
	Mean		32	38	40·6	16·4	3·8	..	1·2	

It would be seen from Table I that

(i) Flowering is a process extending gradually from shoot to shoot in a tree.

(ii) A tree flowers completely in 32 days on an average. Wide variation is noticed between trees even in respect of this character.

(iii) In December, 78·6 per cent of the shoots had flowered while during February, the flowering was stray.

The period of flower production generally extends from the earlier half of December to the latter half of April.

The intensity of flowering during the various months of the flowering season is summarised in the Tables II, III and IV.

Table II

Intensity of flowering during the various months

No. of shoots under observation : 20 per tree

Total No. of shoots flowered in 5 trees : 84

F.N.=Fortnight

Tree No.	Total number of perfect flowers produced during									
	December, 1954		January, 1955		February, 1955		March, 1955		April, 1955	
	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.
1	1641	4,028	1,790	600	44	24	7	..	..	..
2	..	225	889	1,084	784	698	742	490	182	80
3	5	309	958	916	y70	446	344	211	45	4
4	65	419	667	650	403	233	201	235	133	87
5	166	1,439	1,666	1,324	907	685	597	424	335	87
Total	1,877	6,420	5,970	4,574	2,608	2,086	1,891	1,360	695	158
Mean	375	1,284	1,194	915	522	417	378	272	139	32
*	6·8	23·2	21·6	16·6	9·4	7·5	6·9	4·9	2·5	0·6

* Percentage of mean on total.

TABLE III

Number of hermaphrodite flowers during the various months

No. of shoots under observation : 20 per tree

Tree No.	Total number of perfect flowers produced during									
	December, 1954		January, 1955		February, 1955		March, 1955		April, 1955	
	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.
1	..	21	66	114	25	17	4	..	..	..
2	..	..	..	26	129	122	26	3	..	..
3	..	..	1	40	119	118	70	12	1	..
4	..	..	..	..	12	22	42	10	..	1
5	..	..	..	10	34	31	4	15	1	1
Total	..	21	67	190	319	310	146	40	2	2
Mean	..	4·2	13·4	38·0	63·8	62·0	29·2	8·0	0·4	0·4
*	..	1·9	6·1	17·3	29·1	28·3	13·3	3·6	0·2	0·2

* Percentage of mean on total.

TABLE IV

Intensity of appearance of male flowers during the various months when the tree is in bloom

No. of shoots under observation : 20 per tree

Tree No.	Total No. of male flowers produced during									
	December, 1954		January, 1955		February, 1955		March, 1955		April, 1955	
	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.	1st F.N.	2nd F.N.
1	1,641	4,007	1,724	486	19	7	3	..	..	..
2	..	225	889	1,058	655	576	716	487	182	30
3	5	309	957	876	351	328	274	199	44	4
4	65	419	667	650	391	211	159	225	133	36
5	166	1,439	1,666	1,314	873	654	593	409	334	86
Total	1,877	6,399	5,903	4,384	2,289	1,776	1,745	1,320	693	156
Mean	375·4	1279·8	1,181	876·8	457·8	355·2	349	264	138·6	31·2

It would be apparent from Tables II, III and IV that

(i) the maximum flower production is between the later halves of December and January,

(ii) on an average, a shoot produces 329 flowers,

(iii) nearly 96 per cent of the flowers are staminate while only 4 per cent are bisexual,

(iv) the staminate flowers are produced during all the months when the tree is in bloom while nearly 88 per cent of the hermaphrodite flowers make their appearance between the second half of January and the first fortnight of March, i.e. between 45 and 105 days from the commencement of flowering. Only 8 per cent of the hermaphrodite flowers appear in the earlier phase of the flowering while the remaining 4 per cent is distributed in the later period after March and

(v) the production of flowers shows a decline from the later half of March.

In the course of the above observations it was also noticed that the trees have a marked tendency to commence flowering in the east extending gradually to west in a clockwise direction as seen from Table V which represents the data collected from twelve trees.

TABLE V

Showing the date of commencement of flowering in the different directions

Total number of shoots per tree : 5 in each direction

Tree No.	Date of commencement of flowering in			
	East	South	West	North
1	1st December	5th December	8th December	11th December
2	21st "	27th "	2nd January	6th January
3	15th "	27th "	31st December	6th "
4	9th "	13th "	27th "	8th "
5	3rd "	9th "	13th "	19th December
6	15th "	18th "	24th "	30th "
7	11th "	17th "	17th "	25th "
8	6th "	6th "	13th "	20th "
9	21st "	26th "	27th "	4th January
10	21st "	23rd "	27th "	30th December
11	27th "	30th "	30th "	7th "
12	27th "	1st January	1st January	1st January

5. *Inflorescence*

The flowers are produced in panicles generally at the terminal ends of the current season's growth. The panicles are conical, pyramidal or irregular in shape. Of the panicles under observation, 45 per cent were conical, 40 per cent irregular and 15 per cent pyramidal. The colour of the panicles is a mixture of pink, white and green corresponding to the colour of petals and sepals. Each panicle consists of a number of a laterals ranging between 5 to 11. The total number of flowers

produced in a panicle varies from 21-881 with a mean of 329. The total number of staminate flowers produced by a panicle ranges from 19-876 with a mean of 316. The corresponding figures for hermaphrodite flowers are 1 to 82 with a mean of 13.

6. *Flowers*

The cashew panicle is polygamous with male and hermaphrodite flowers. In an open flower, the lobes of the petal are recurved. The flowers are small, light yellowish green in colour and pentamerous. The calyx is green. The colour of the petal (inside) at the time of anthesis is either pure white or white with faint or distinct logitudinal pink streaks. The colour of the petal (outside) is white. The petals turn completely pink on the second or third day. The anther is rounded and pink in colour and turns grey at the time of dehiscence. The ovary is pale yellow with a pink spot at the junction with the style. The colour of the ovary changes to pink completely after fertilization. The style is pale white to creamy white. The stigma is needle shaped and creamy white.

In a staminate flower, there are five sepals, five petals and 7-10 stamens of which one is exserted while the remaining are staminodes which are inserted. In a hermaphrodite flower, there are five sepals, five petals, the andrœcium consists of 7-10 stamens of which one is exserted and the rest staminodes and inserted ; the gynœcium consists of the ovary, style and stigma. The stigma and one stamen are protruding outside, the former being taller than the latter. The petals of a hermaphrodite flower are always broader than those of the male flower. The mean measurements of the floral parts recorded in 10 trees are furnished in the table VI.

TABLE VI

Measurements of floral parts

Number of flowers examined : 20 per tree

Tree No.	Staminate flower				Hermaphrodite flower						
	* Calyx (mm.)	* Corolla (mm.)	* Stamen	* Staminodes (mm.)	* Calyx (mm.)	* Corolla (mm.)	* Stamen (mm.)	* Staminodes (mm.)	* Style (mm.)	**	* †
1	4	11	9	2	5	12	4	2	9	5	32
2	4	12	10	2	5	14	7	2	10	3	85
3	4	11	9	3	4	11	6	2	10	4	20
4	4	12	10	4	4	12	5	2	10	5	12
5	4	12	10	2	5	12	5	2	10	5	13
6	4	11	10	3	4	11	6	3	10	4	92
7	4	10	10	3	4	11	6	3	10	4	30
8	4	11	10	3	5	11	4	2	8	4	37
9	4	10	9	3	5	12	5	2	10	5	8
10	4	11	11	4	5	12	5	2	10	5	10
Total	40	111	98	29	46	118	53	22	97	44	
Mean	4	11·1	9·8	2·9	4·6	11·8	5·3	2·2	9·7	4·4	

*Mean length of
** Distance from anther to stigma.
† Yield in lb. of nuts.

It would be seen from Table VI that (*a*) there is variation from tree to tree regarding the sizes of floral parts, (*b*) the hermaphrodite flowers are slightly larger than the male flowers, (*c*) the stamen of the staminate flower is always longer than that of the perfect flower and (*d*) there are indications of a better fruit set when the distance between the stigma and anther is short.

7. *Anthesis*

The peak anthesis was found to be between 9-11 a.m. The hermaphrodite flowers start opening from 9-10 a.m. onwards and continue till 1 P.M. but do not open at other times while some of the staminate flowers are seen to open even before 9 a.m. though in small numbers and continue till about 3 p.m. after which no flowers generally open.

8. *Stigma receptivity*

The stigma is found receptive throughout the day but withers and loses the receptivity the next day.

9. *Anther dehiscence*

Anthers start dehiscing from 10-30 a.m. onwards, turning grey from pink at the time of dehiscence.

10. *Pollen longevity*

The pollen grains remain viable for a period of 48 hours.

11. *Fruit set*

The apple and nut together form the fruit. The apple is only an expanded, swollen and sappy pedicel bearing the real fruit which is the nut. In its natural position, the fruit hangs with the nut at the very tip and the swollen portion or " apple " just above the seed. The apple makes up greater part of the fruit being 90·5 per cent while the nut is 9·5 per cent of the weight of the fruit (means of 100 samples). In the very young stages, the nut is generally pink and then the colour changes to green, while in certain trees the nut when it is first visible is green. At this stage, the nut is very much larger than the apple. The colour of the nut changes from green to greenish grey and finally ash grey. As the fruit develops, the apple becomes much larger than the nut and turns yellow or red or a mixture of red and yellow on ripening, while the nut diminishes in size and turns brownish or ash grey (Plate I).

The nut consists of a husk or pericarp which is a thick and rather hard cellular shell with oil enclosing the reniform seed. The seed is covered with a thin light pink or reddish brown testa and has the white kernel made up of the cotyledons.

Observations on the development of fruits produced under controlled conditions revealed that from the date of fertilization (*a*) the developing nut is visible to the naked eye in five days, (*b*) the pink colour of the nut changes to green in 20

(*a*) Different Stages in the development of the fruit

(*b*) Cross-Section of the developing fruit showing the kernel

(*c*) Cashew Inflorescence

days, (*c*) the seed develops completely inside the shell cavity in about 35 days, (*d*) the rudimentary apple exceeds the size of the developing nut in about 45 days, (*e*) the tender nut reaches the maximum size in about 40 days and thereafter shrinks and hardens and (*f*) the fruit (apple and nut) ripens fully in 60 days. (Fig. 1).

Out of 100 tagged shoots, 84 flowered during the season, of which only 22 carried fruits. No fruit set was noticed in the remaining shoots although a large number of hermaphrodite flowers were produced. It would thus be seen that all panicles containing hermaphrodite flowers do not necessarily produce fruits and the fruits that set are not all carried to maturity.

The fruit set per shoot under natural open pollinated conditions worked out to three per cent of the total number of perfect flowers produced. But more encouraging results were obtained when hand pollination was done. Out of 54 flowers hand pollinated 30 set fruit, the percentage working out to 55·5.

In order to test the efficacy of spraying water over the blossoms as a means of artificial pollination, two trees in bloom in a neighbouring plantation were selected and one section of each was sprayed with water four times during March-April with an interval of six days between each spraying, while the opposite side was untreated. The results, which may indirectly indicate the responses of a tree to showers received during the blossoming season, showed that as against a set of 30 fruits in the sprayed section only 14 were recorded in the untreated portion. It is likely that spraying would have been more beneficial during January-March when the flowering was more intense.

12. *Insect visitors and pollination*

Except black and red ants no other insects were seen to infest the panicle during October-May. The ants were seen in the panicles throughout the day.

13. *Cloudy weather and blossoming*

The effect of cloudy weather on the inflorescence of the tagged shoots was studied and the data gathered are presented below.

TABLE VII

Effect of cloudy weather on blossoming

Date	Nature and extent of cloudiness	Percentage of panicles: Slightly scorched	Half scorched	Fully scorched	Remarks
10th and 11th February, 1955	Cloudy during night and forenoon	40	45	15	Counts taken on 12-2-55.
3rd and 4th March, 1955	Cloudy almost throughout the day	30	30	40	Counts taken on 5-3-55.

FIG. 1

A—Inflorescence

B—Staminate flower

C—Hermaphrodite flower

D—Pistil, stamen and staminodes (hermaphrodite flower)

E—Stamen and staminodes (Staminate flower)

Although the above data are confined to observations recorded on four days, the results seem to indicate that the widespread belief of growers about the detrimental effect of cloudy weather on blossoming is not completely wrong. Further studies seem necessary to arrive at definite conclusions.

Discussion

Unlike the mango which bears its crop on the past season's wood the cashew produces flowers on the current season's flushes and, therefore, any natural factor which serves to promote the growth extension may be said to be responsible for fostering the yields. In mango, however, such an active condition prior to blossoming as observed by Naik and Mohan Rao[2] is invariably detrimental to satisfactory cropping. The lateral shoots in cashew seem to have as important a role as in mango in determining the cropping. It is however, noticed that although there are two distinct growth flushes in the season, it is only during the earlier phase from October-January that the shoots give rise to panicles while the later flushes in March-May are invariably unproductive. The subsequent behaviour of the flowered and non-flowered shoots among those tagged for study during the first year is expected to form a separate subject for study in due course.

The almost negligible percentage of hermaphrodite flowers produced during December, i.e. the first month after commencement of flowering and the intensity of their appearance between the second and third months are interesting phenomena. This may perhaps account for the "drying up" of inflorescences noticed during certain periods of the flowering obviously due to the shedding of the staminate flowers which predominate in the first month and towards the end of the season and which is perhaps mistaken for a disease. The percentage of hermaphrodite flowers is as low and varying as in mango ranging from 1·2 to 9·7 per cent with a mean of 4·0 per cent in five trees under study while the ultimate percentage of successful set works out only to 3 per cent of the total number of hermaphrodite flowers produced. The absence of adequate pollination in nature seems to be responsible for the low set. This is amply demonstrated by the phenomenal increase in fruit set, amounting to as much as 55 per cent under artificial conditions. The role of insects as far as these observations are concerned appeared to be insignificant and the only natural factor that aided pollination was wind. It seems, however possible that the percentage of set may be higher in situations where the cashew is found mixed with other vegetation with greater scope for activity of insects.

Peculiarly enough, the period of the peak production of hermaphrodite flowers in January and February coincides with the dry weather period, which is characterised by absence of wind or rain in normal years. One or two showers during this period, provided they are not very heavy, may be expected to aid the pollination considerably as has been observed by many growers. The possibility of securing higher yields under such circumstances is also indicated by the spraying trials, the results of which are also dealt with in this paper.

Quite apart from the influence of natural factors on the cropping behaviour it has to be conceded that the yield of a tree is governed primarily by the extent of hermaphrodite flowers produced, and that this is a character inherent in the tree

and not subject to any manipulations in the cultural practices. Naik and Mohan Rao[2] found a definite positive correlation between the percentage of perfect flowers in the panicles and the number of fruits borne, which varied with each variety of mango. The need for selection of individual trees with a preponderance of perfect flowers is, therefore, obvious.

The distance between the anther and the stigmatic end which is generally a variable factor in different types deserves consideration in selection of a desirable parent, as revealed by the results in this investigation. Shorter style length, and lower ratios of style length to stamen length have been observed by Naik and Mohan Rao[2], to be helpful in securing better set of fruits in mango by means of open pollination.

The preliminary observations reported in these pages lend ample support to the popular belief that cloudy weather at the time of flowering even for a short spell is responsible for shrivelling and withering of panicles resulting in considerable reduction in yields. The mango is also known to be subject to such an influence, the exact causes for which are not, however, known at the moment.

The physiological aspect of the flowering with reference to the aspect of the tree and the sunlight seems to be an interesting study deserving pursuit.

Summary

1. Observations on the development of 100 tagged shoots from the period of dormancy to fruiting are summarised.

2. The panicles, flower and fruit of cashew are described. Data on the period of flowering, intensity of flower production, percentage of hermaphrodite and staminate flowers, the relationship between style and stamen length, anthesis, stigma receptivity, anther dehiscence, pollen longevity and fruit set are presented.

3. The mode of pollination in cashew, effect of cloudy weather on flower production and results of controlled pollination are dealt with.

Acknowledgment

The authors are grateful to Shri U. Narasinga Rao, Horticulturist and Professor of Horticulture, Coimbatore for his guidance in the conduct of the investigations and to Shri D. Daniel Sundararaj, Lecturer in Botany, Agricultural College and Research Institute, Coimbatore, for his helpful criticism and suggestions in the preparation of this paper. The material presented in this paper refers to an item of work under the programme of the Cashewnut Research Scheme, Mangalore, which is partly financed by the Indian Council of Agricultural Research.

References

1. Annon (1954). *Memoirs of the department of Agriculture*, Madras. Superintendent, Government Press, Madras. Pp. 647-654.

2. Naik, K. C. and M. Mohan Rao (1941). "Crop Behaviour in Mangoes" *Mardas Agric. J.* Vol. XXIX, No. 7.

3. Morada, E. K. (1941). "Cashew Culture" *Phillippine J. Agric.* Vol. 12, No. 1.

STUDIES ON SEED VIABILITY IN CASHEW

By V. N. Madhava Rao, I. K. Sambashiva Rao and M. Vazir Hassan,

Central Cashewnut Research Station, Mangalore

[Received for publication on September 17, 1956
Accepted for publication on November 15, 1956]

The existing methods of cashew growing in the important areas such as Madras, Travancore-Cochin and Andhra States are not uniform specially in respect of the choice of seed material for sowing. In many areas seeds of the current season are preferred, while in some parts of Madras State seeds of the previous season are selected for sowing ; in a few areas in Malabar and Travancore-Cochin State even immature seeds in the green state are selected for sowing[2]. The reasons for these preferences are not, however, clear. So far as the germination is concerned, trials at the Cashewnut Research Station, Mangalore have shown that the seeds of the current season, and of the "green" stage both gave almost cent per cent germination[2]. In order to gather precise data on the period of viability of the seeds under normal conditions of storage, trials were initiated at the Central Cashewnut Research Station, in February, 1955, and conducted over a period of 16 months. A parallel series of studies on the storage of seeds in different kinds of containers and thier consequent effects on germination was also undertaken. Another trial to investigate the influence of pre-soaking the seeds in water on germination was also undertaken. The results of these trials are reviewed in this article.

Review of Literature

In an earlier investigation[2], the authors have reviewed the results of studies in germination of cashew seeds, dealing with optimum maturity, weight and size of the seed to be selected and depth and position of sowing seeds. There appears to be no record of the viability of cashew seeds, nor of the effects of storage on the germination of cashew seeds. Literature on other crops having a bearing on the experiments dealt with in this article has, therefore, been reviewed.

Viability

Paddy[1] germination tests conducted at monthly intervals with *GEB 24* seed, showed that the viability remained unimpaired for 13 months after harvest. There was a steady decline in viability down to 80 per cent after 24 months of storage. This figure was maintained till 33 months after the harvest. Viability studies showed that groundnuts[1] remained viable for about four years if the seeds were stored in air-tight containers but under ordinary conditions, e.g. in gunny bags lost viability in about a year.

Pre-soaking

In paddy[1], delayed germination of seeds was overcome by soaking for longer periods in water before sowing. In *ragi*[1], seeds pre-soaked in a 10 per cent solution of bovine urine were found to yield enhanced crops of grain and straw.

Storage

Paddy seeds were stored well in ordinary gunny bags but became mouldy if stored in closed metal bins. Sorghum grains intended for seed are generally stored in gunny bags. Sometimes these are also stored in bamboo receptacles or in twisted straw bundles. Coconuts preserved in sand[1], kept well for a period of nine months. Nuts stored loose for the same period were found dry and unfit for seed purposes. In cotton[1] no difference was found in germination between the seeds stored in single and double gunnies even at the end of one year.

Material and Methods

The trials dealt with in this article were conducted with cashew seeds from a single selected tree near the Cashewnut Research Station, Ullal, Mangalore, collected during February-May 1955. The details under each of the trials are given below.

Viability of seeds

In order to determine the viability of seeds during different months after harvest and to determine the stage where there is no germination at all, a trial was initiated in February, 1955. Fifty seeds from a single selected tree were sown every month from March, 1955 onwards in rows in nursery beds. Data on germination were recorded. All the seeds used in this trial were from the produce harvested in the month of February, 1955 and during the period of trial, the seeds were stored in tin containers closed with lids (not air-tight). The trial was continued till the viability was lost completely.

Pre-soaking and germination

To determine the effects of pre-soaking on the germination of cashew seeds, another trial was initiated. Seeds collected from a single tree in February, 1955 were utilised in October, 1955, (i.e. when eight month old), after subjecting them to the following treatments :

(i) Pre-soaking for 24 hours in cold water.

(ii) Pre-soaking for 48 hours in cold water.

(iii) Control (untreated).

Eight-month-old seeds were selected for the trial because after eight months a fall was noticed in the germination percentage. The object of the trial was to find out whether the higher germination percentage could be maintained by pre-soaking. Twenty-five seeds were subjected to each treatment during every month from October, 1955 till the viability was '*nil*' under all the treatments.

Storage and viability

To test the viability of cashew seeds stored under different conditions, seeds from a single tree were dried in the sun for two days (16 hours), and stored in the following containers :

(i) Single-gunny bags ;

(ii) Double-gunny bags ;

(iii) Paddy straw after treatment with ash,

(iv) Tins with lid closed (not air-tight),

(v) Tin with lid closed and sealed with paraffin wax,

(vi) Seeds wrapped in Alkathene film (100 gauge) and stored in tins.

After six months of storage, 40 seeds from each of the treatments were sown in monthly intervals from the 14th October 1955 until one-year-old seeds of all the treatments were sown. Data on germination and the number of days taken for germination were recorded.

Results

Viability of seeds

A summary of observations recorded under this trial is given in Table I.

Table I

Cashew—viability tests

Month of sowing	Age of seeds in months	No. of days taken for germination to commence	Percentage of germination
March (1955)	1	13	100
April ,,	2	14	100
May ,,	3	13	100
June ,,	4	13	100
July ,,	5	14	98
August ,,	6	13	92
September ,,	7	13	96
October ,,	8	13	80
November ,,	9	19	68
December ,,	10	21	56
January (1956)	11	22	16
February ,,	12	22	24
March ,,	13	20	4
April ,,	14	0	0

The results show that

(i) During the first four months after harvest the viability is cent per cent.

(ii) During the first seven months after harvest the viability continues to be high (above 90 per cent).

(iii) A sharp fall in the percentage of germination is noticed after the eighth month, decreasing progressively till it is zero during the 14th month after harvest.

(iv) The germination is found to be delayed with the increasing age of the seed.

Pre-soaking and germination

The percentage of germination recorded in each of the treatment and the number of days taken for the germination to commence are summarised in Tables II and III.

TABLE II

Germination of pre-soaked seeds

Treatment	8 months old	9 months old	10 months old	11 months old	12 months old	13 months old	14 months old
1. Pre-soaked for 48 hours	88	92	68	24	28	12	0
2. Pre-soaked for 24 hours	100	80	60	16	24	4	0
3. Control (untreated)	84	68	56	15	24	4	0

TABLE III

Germination of pre-soaked seeds

Treatment	Number of days required for germination						
	8 months old	9 months old	10 months old	11 months old	12 months old	13 months old	14 months old
1. Pre-soaked for 48 hours	12	16	17	20	20	17	Seeds did not germinate.
2. Pre-soaked for 24 hours	13	18	19	20	20	21	
3. Control (untreated)	14	19	21	22	22	20	

Tables II and III show that (i) pre-soaking of seeds has given slightly higher percentage and earlier germination than the control from the eighth month of storage onwards, (ii) viability is completely lost during the 14th month of storage when even pre-soaking does not help germination.

Storage and viability

A summary of the observations recorded under this trial is given in Table IV.

TABLE IV

Storage and viability—percentage of germination

Containers	6 months old	7 months old	8 months old	9 months old	10 months old	11 months old	12 months old	Mean percentage of germination for each treatment.
Single gunny	27·5	*nil*	2·5	*nil*	*nil*	*nil*	*nil*	4·3
Double gunny	25·0	10·0	5·0	5·0	*nil*	*nil*	*nil*	6·4
Paddy straw	65·0	25·0	7·5	2·5	2·5	*nil*	*nil*	14·6
Tin-lid closed	97·5	100·0	92·5	97·5	97·5	95·0	95·0	96·4
Tin-lid closed and sealed with wax	100·0	100·0	97·5	90·0	100·0	100·0	97·5	97·9
Alkathene and tin	100·0	100·0	97·5	95·0	97·5	95·0	77·5	94·6

The results show that:

(i) Among the six treatments, the highest germination has been recorded by seeds stored in tins with lids closed as well as those in which the lids were sealed with wax and seeds wrapped in Alkathene film. The germination of seeds stored in single gunny, double gunny and paddy straw has been poor.

(ii) For retaining viability of seeds, the local methods of storage or preservation in gunnies or paddy straw cannot be recommended.

(iii) Seeds could be stored in Alkathene packing or air-tight tin containers for one year without impairing the viability.

There was no appreciable difference between the treatments in respect of the time taken for germination from the date of sowing.

Discussion

The trials have shown that cashew seeds under normal conditions of storage in gunnies and paddy straw without any attention to the air-tight condition lose viability rapidly. Even when stored in tins with the lids somewhat loose the germination falls progressively, with 16 per cent in the eleventh month, 4 per cent in the thirteenth month and total loss of viability in the fourteenth month. Pre-soaking of seeds in water does not seem to enhance the rate of germination appreciably. The trials on storage have, however, proved that under air-tight conditions of storage, the viability can be preserved for a year to as high a degree as during the first few months after collection of seed. For preserving viability, storing of seeds in the ordinary grass, straws or tin receptacles without adequate safeguards against exposure cannot be recommended. It may not, however, be necessary to store seeds beyond a 12-month period because by then fresh seeds become available.

Summary

1. Cashew seeds stored in tin receptacles with no special attention to air-tight condition, were found to give between 80 and 100 per cent germination till eight months after collection.

2. The viability under the above conditions of storage was lost completely in 14 months.

3. Pre-soaking of seeds did not increase the percentage of germination appreciably.

4. Seeds stored in gunny and paddy straw lost viability completely at the end of 11 months as against 95 to 98 per cent recorded by those stored in air-tight containers.

Acknowledgments

The authors are grateful to Shri U. Narasinga Rao, Horticulturist and Professor of Horticulture, Agricultural College and Research Institute, Coimbatore for his guidance in the conduct of the trials undertaken at the Central Cashewnut Station, Ullal, Mangalore under the scheme for research on cashewnut, financed partly by the Indian Council of Agricultural Research.

References

1. Anon (1954). *Memoirs of the department of Agriculture*, Madras, Superintendent, Government Press, Madras

2. Madhava Rao, V. N., I. K. Sambashiva Rao and M. Vazir Hassan. (1956). Studies on certain aspects of germination of seeds in cashew (*Anacardium occidentale* Linn) (in Press) *Indian J. Agric. Sci.*

STUDY ON THE ASSESSMENT OF DAMAGE DONE BY *HISPA ARMIGERA* OL. TO PADDY CROP

By A. C. Basu and S. N. Banerjee, State Agricultural Research Institute, Calcutta

[Received for publication on January 13, 1956
Accepted for publication on November 11, 1956]

(With 1 Text Figure)

An assessment of the damage done by any specific insect to its crop host is quite a difficult problem and more so in the cases of the insects about which definite symptom of damage has not been recorded. But, the peculiar character of damage made by *H. armigera*, a chrysomelid beetle has been described and established well by many authors, such as, Fletcher [1913], Pillai [1921], Ballard [1921], Sen [1921], Ghosh [1923], Fey [1925], Hadden [1928], Gupta [1929], Jen [1930], Ladell [1933], Ramkrishna Ayyar [1933], Hedayetullah [1941] and Agarwala [1945], so that there can be no possible chances of error if the assessment is based on the known characteristic damage of *H. armigera* to the paddy leaf.

In this article it has been attempted to assess the area of paddy leaf damaged by the beetle, *Hispa armigera* and to find out the intensity of attack at different ages of the winter paddy crop.

Methods and Observations

In this experiment, the growth period of the winter paddy crop was divided into 4 stages such as (*a*) seedling stage, (*b*) transplanted stage, (*c*) flowering stage and (*d*) grain stage or the mature stage. The variety of paddy selected for this experiment was Bhasamanik. The observations were taken from these four stages of the crop. For recording the percentage of leaf area damaged, standard charts were prepared by outlining the paddy leaf of each stage on a square graph paper of the specification of 10 divisions in 1 sq. inch and then by calculating proportionate percentage of damage at different levels ranging from 0·1 per cent to 15 per cent was marked in the outlined leaf drawings. Thus for each stage of the crop 14 standard leaf charts were drawn showing 0·1 per cent, 0·5 per cent, 1·0 per cent, 1·5 per cent, 2 per cent, 2·5 per cent, 3 per cent, 3·5 per cent, 4 per cent, 4·5 per cent, 5 per cent, 7 per cent, 10 per cent and 15 per cent damaged leaf area. The healthy leaf was counted as zero per cent damage. So altogether 56 standard damaged leaf charts were prepared, comprising 14 for the seedling stage, 14 for the transplanted stage, 14 for the

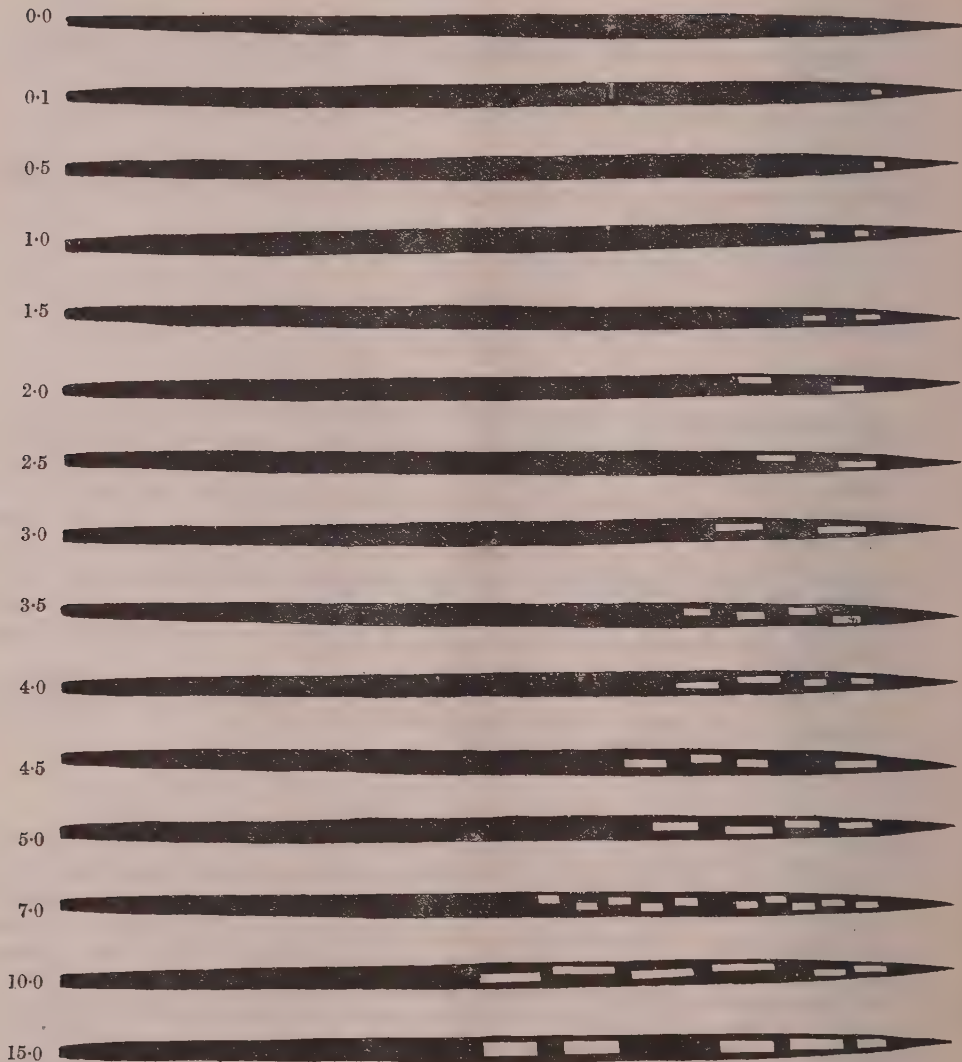


FIG. 1 Standard leaf chart showing the percentage of paddy leaf area damaged by *H. armigera* in the seedling stage of the crop

flowering stage and 14 for the grain stage of the paddy crops. The standard paddy leaf damages of the seedling stage are shown in the Fig. 1. The standard paddy leaf damages of the other stages of the paddy crop are not shown here.

The experimental leaf samples were picked up at the different growth periods of the crop befitting the proper stage of the crop. Thus the leaf samples from the seedlings stage were collected when the age of the crop was 4 weeks ; the leaf samples from the transplanted stage were collected when the age of the crop was 8 weeks ; the leaf samples from the flowering stage were collected when the age of the crop was 12 weeks and similarly in the grain stage when the age of the crop was 16 weeks.

The stage or treatment was replicated four times. So there were altogether 16 plots, each plot measuring 1/40 acre [33 ft. × 33 ft.]. These plots were grouped in 4 blocks. The treatments and the replications were arranged at random. In assessing the area of leaf-blade damaged by *H. armigera*, leaf samples of paddy from each stage or treatment numbering 300 were collected from 1/40 acre of paddy land and in doing so, the 1/40 acre of land was divided into six units and 50 leaves at andom were picked up from each such unit or sub-plot.

A sample of 300 paddy leaves from the paddy seedlings comprising healthy and damaged leaves was collected from each replicate and thus from 4 replicates altogether 1,200 samples of paddy leaves were collected in 4 sets. These leaf samples were taken to the laboratory for assessing the percentage of the leaf area damaged by comparing them with the standard digramatic damaged leaf charts. After the examinations of 300 paddy leaves in the laboratory and the number of times a particular value of the percentage of area damage recur according to the standard chart, were noted. Next to calculate the mean value of the observations, a frequency distribution table was drawn. In this table the first column, headed X, showed the values of the different percentage of damage which were marked in the standard chart and the second column, headed F, showed the number of times or frequency of occurrence of each. The next step was to write down a third column headed FX, which was produced by multiplying together the corresponding pairs of number in X and F column. The arithmetic mean value on the percentage of leaf area damaged was obtained by using the formula $\bar{X} = \frac{\Sigma(FX)}{N}$ where N is the sum of F column which is the number of the collected samples of 300 paddy leaves. The mean value thus obtained in each replication as well as in each stage of the crop is shown in able I. The experiment was carried for six years from 1949 to 1954 and the data of the experiment collected during the entire period of the experimentation are shown in the Table I. The results of the experiment were analysed statistically.

Results and Discussion

Exact measurement of a leaf area may be obtained directly by means of a planimeter, by photo-electric determination or by estimation with the aid of a standard graph paper. In the present article, graph papers have been used in preparing the standard chart for grading the samples of the damaged leaves. This method of

assessment is quite common amongst the mycologists. They frequently adopt this method for the assessment of area damaged in a fruit or a leaf by a fungus and is known as Cob's chart as stated by Chester [1948]. Chattopadhya [1952] has applied this method in the assessment of infection of *Helminthosporium oryyzae*; Breada De Hann on paddy in West Bengal; Hansbery [1943] used a method similar to this in estimating leaf area consumed by insect in the chemical control of insects. Banerjee and Mookherjee [1955] have very recently estimated the damage done by *Tanymecus sciurus* Olv. to sugarcane leaf by cross paper.

The damage done by *H. armigera* is often expressed loosely to be 40 to 50 per cent, possibly by guessing the density of the population of *H. armigera* or by eye-estimation, but very little effort has so far been made to assess the damage inflicted to paddy plantations by *H. armigera*, by any standard method.

Table I gives a trend of the damage inflicted by *H. armigera* to paddy leaves at different stages of the paddy crop. Now in studying the mean per cent of damage suffered in the seedling stage during the period of six years, it is found that the crop to this stage was subject to the minimum damage of 1·53 per cent and the maximum damage of 3·86 per cent and the arithmetic mean of the six years' average damage comes to 2·14 per cent. The transplanted stage of the crop was subject to the minimum damage of 2·71 per cent and the maximum damage of 6·28 per cent and the arithmetic mean of six years' average damage comes to 4·06 per cent. Similarly, the flowering stage of the crop was subject to a minimum damage of 0·35 per cent and a maximum damage of 0·68 per cent and the arithmetic mean of six years' average damage comes to 0·54 per cent. The grain stage of the crop was subject to a damage of 0·12 per cent in the year 1952 only and during the remaining five years this stage appeared to escape the attack of *H. armigera*. The arithmetic mean of six years' average damage comes to 0·02 per cent. Now in summing the arithmetic mean damages of the seedling stage, transplanted stage, flowering stage and grain stage, the value comes to 6·76 per cent in all.

Table I also advances the total damage done by *H. armigera* year after year to the winter paddy from the seedling stage to the grain stage. Now in summing the vertical mean values of the column of the experimental result of 1949 it is seen that the winter crop of that year was subject to 5·11 per cent damage; the total damage to the winter paddy leaves was 5·63 per cent in 1950; 8·20 per cent damage in 1951; 5·97 per cent damage in 1952; 7·09 per cent damage in 1953 and 8·47 per cent damage in 1954. The over-all average of the six years' observations on the total damage to the leaves of winter paddy comes to 6·76 per cent.

It has often been said that *H. armigera* damages the seedling stages; this is obviously because the transplanted stage of paddy is confused with the seedling stage of the crop. If the node formation in the crop is considered as a criterion for separating the transplanted stage from the seedling stage it will be found that *H. armigera* inflicts more damage to the paddy at the transplanted stage than in the seedling stage. This is because the damage is dependent on the population density

TABLE I

Assessment of damage done by H. armigera *to paddy plantation*

Treatment	Code mark	No. of sample	Replication	Per cent leaf area damaged per year 1949	Mean	1950	Mean	1951	Mean	1952	Mean	1953	Mean	1954	Mean	Total of six years' mean	Average of six years
Seedling stage	A	300	I	1·50		1·80		2·50		1·80		7·30		0·95			
		300	II	2·10	1·67	1·60	1·57	2·85	2·31	2·15	1·91	4·20	3·86	1·85	1·53	12·85	2·14
		300	III	1·20		1·15		2·05		1·65		2·10		1·25			
		300	IV	1·90		1·75		1·85		2·05		1·85		2·10			
Transplanted stage	B	300	I	2·90		3·10		4·50		2·80		0·85		5·14			
		300	II	3·15	2·96	2·95	3·51	5·30	5·21	2·95	3·71	1·95	2·71	6·25	6·28	24·88	4·06
		300	III	1·80		3·80		4·80		3·85		3·75		4·78			
		300	IV	4·02		4·20		6·25		5·25		4·35		8·25			
Flowering stage	C	300	I	0·50		0·30		0·80		0·20		0·40		0·61			
		300	II	0·30	0·48	0·40	0·55	0·95	0·68	0·80	0·35	0·50	0·52	0·35	0·66	3·24	0·54
		300	III	0·95		0·65		0·35		0·10		0·85		0·95			
		300	IV	0·20		0·85		0·65		0·80		0·35		0·75			
Grain or mature stage	D	300	I	0·00		0·00		0·00		0·00		0·00		0·00			
		300	II	0·00	0·00	0·00	0·00	0·00	0·00	0·00	0·12	0·00	0·00	0·00	0·00	0·12	0·02
		300	III	0·00		0·00		0·00		0·48		0·00		0·00			
		300	IV	0·00		0·00		0·00		0·00		0·00		0·00			
TOTAL					5·11		5·63		8·20		6·09		7·09		8·47	4 ·59	6·76
S.E.				0·26		0·17		0·25		0·38		0·86		0·42			
C. D. at 1 per cent level				0·83		0·53		0·79		1·05		2·75		1.33			
at 5 per cent level				1·93		0·76		1·13		1·57		..		1·99			

of *H. armigera*. The experiments show that the incidence of this insect, although is noticed in the seedling stage, the population takes a filip during the transplanted stage of the crop. This rise in the population of *H. armigera* again dwindles down in the late period of the transplanted stage of the crop. Evidently, the peak period of the population of this insect appears at the transplanted stage of the crop. Hence the transplanted stage of the paddy is more prone to the attack of *H. armigera* than the other stages of the paddy crop. Again it is often that no recognition is given to the damage done by *H. armigera* at the late stages of the crop. But a careful consideration of the general principles of insect population will reveal that the nature of the population curve of this insect may either be a normal probability curve or an abnormal one ; but whatever the shape of distribution of the population is, it is definite that it begins from a zero population and again ends at zero population. Evidently, this insect, *H. armigera*, while descending from the peak period of the population to zero population, cannot remain idle without damaging the paddy plantation, be it in the flowering stage or in the grain stage. The results from the present work on the damages caused by *H. armigera* to the flowering stage and very rarely the grain stage of the crop, corroborate this.

A critical review of the data of the six years observations reveal that the percentage of damage in the transplanted stage of paddy was highest in five year and only in 1953 the percentage of damage in the seedling stage supersedes the damage in the transplanted stage. This may be due to the higher incidence of *H. armigera* at a period earlier than the normal season of incidence or possibly for having an abnormal population curve with a steep rise due to the high number of beetles in the beginning of the emergence in the year 1953. And for this the seedling stage faced the greater percentage of damage. Particularly the abnormal increase in the percentage of attack made by *H. armigera* in the replicates I and II respectively leads to this conclusion. Barring the result of 1953, all the results of five other years have followed a similar trend showing the damage by *H. armigera* to be highest in the transplanted stage, second in the seedling stage and third in the flowering stage. The statistical analysis also corroborates this conclusion.

The data of the individual year were analysed statistically and the results of the analysis of variance of five years have been found to be highly significant at 1 per cent level and only significant at 5 per cent level in the year 1953. The analysis provides that amongst the four stages of growth, the attack of *H. armigera* is significantly higher in the transplanted stage of the paddy crop.

Summary and Conclusion

Experiments were carried for six years to assess the damage done by *H. armigera* to paddy leaves at different periods of its growth. The period of plant growth was divided into four stages, such as (*a*) seedling stage, (*b*) transplanted stage, (*c*) flowering stage and (*d*) grain stage or mature stage. These 4 treatments were replicated 4 times. The samples of leaves numbering 300 collected from each treatment of a replicate were graded by comparing them with the standard leaf charts with marking of damage percentages ranging from 0·1 to 15·0 per cent. The observed values were

fitted in a frequency table according to the percentage of attack by *H. armigera.* The data of every year were analysed statistically and the results of the analysis of 5 years have been found to be highly significant and in one year only significant.

The results of the experiment have established that *Hispa armigera* damages leaves to an extent of 2·14 per cent in the seedling stage, 4·06 per cent in the transplanted stage, 0·54 per cent in the flowering stage and 0·02 per cent in the grain stage of the crop and from sowing to harvesting of the paddy crop 6·76 per cent.

Acknowledgment

This paper forms a part of the investigations carried under the research scheme " Investigation on the Insect Pests of Paddy in West Bengal ", which was financed by the Indian Council of Agricultural Research, New Delhi and the State Government of West Bengal on 50 : 50 basis.

REFERENCES

Fletcher, T. B. (1913). Notes on insects attacking the paddy in Southern India. *Mad. Dept. Agri. Bull*, Madras, *iii*, No. 67 : 10

Pillai, R. M. (1921). Short notes on the insect pests of crops in Travancore. *Travan. Dept. Agri.* Trivandrum

Ballard, E. (1921). Additions and corrections to the list of crop pests in South India. *Rept. Proc.* 4th Ento. Meet. Pusa

Sen, P. C. (1921). Rice Hispa. Bengal. *Agri. J.*, *i*, No. *1*, Dacca

Ghosh, C. C. (1923). A note on the Rice Hispa (*Hispa armigera*) *Rept. Proc. 5th Ento. Meet. Pusa*

Fey, K. Y. (1925.) *Hispa armigera*, a rice leaf beetle and its control. *Bur. Ent.* Chikiang, *Pop. Bull. 14*, Kashing, China. (Abstract in English)

Hadden, F. C. (1928). Some injurious Insects of Formosa. *J. Pan-Pacific. Res. Inst. iii*, No. *1* Honolulu, Hawaii

Gupta, S. R. (1929.) *Rep. Dept. Agri.* Assam, Shillong

Jen, Ming-Tao (1930). *Hispa armigera*, the armour weevil. *Misc. Pub. Bur. Ent.* Chekiang *Proc.* No. *3*, Kashing, Chekiang. (Summary in English)

Ramkrishna Ayyar, T. V. (1933). Some important Insect problems connected with the cultivation of Rice in South India. *Agri. Livestock India.*

Ladell, W. R. S. (1933). Insects injurious to Rice in Siam. *J. Siam. Soc., Nat Hist.* Suppl. No. *9* Bangkok

Hedayetullah, S. (1941). Annual Report of the Economic Botanist, Bengal pt. 11 : 1-8

Hansberry, R. (1943). Testing stomach insecticides in laboratory procedures in studies of the chemical control of Insects. *Amm. Assc. Adv. Sci.* 85-94. Washington

Chester, K. Starr. (1948). Nature and Prevention of Plant diseases, Blackiston Company, Tornato

Chattopadhya, S. B. (1952.) Assessment of infection of *Helminthosporium oryyzae* Breda De Mann, on paddy. *Abst. Proc. Indian Sci. Congr.*

Banerjee, S. N. and A. L. Mookherjee (1955). On some aspects of *Tanymecus Sciurus* Olv. a sugarcane beetle and its control in West Bengal (In press)

Agarwala, S. B. D. (1955). On the control of Paddy Hispa (*Hispa armigera* Ol.) *Indian J. Ent.* **17** : **11**: **16**

SOME NEW ORGANIC MERCURIALS

By P. R. Malhan and A. R. S. Kartha, Indian Agricultural Research Institute, New Delhi

[Received for publication on November 2, 1955
Accepted for publication on August 4, 1956]

ORGANIC mercury compounds which have been widely exploited for their fungicidal activity [Frear, 1948 ; Subba Rao, 1952] are of the type R-Hg-X, where R is simple or substituted alkyl or aryl group and X is a halide, hydroxyl or acyl radical. Some compounds of this type are formed when mercuric acetate acts on compounds containing aromatic rings, *e.g.*, benzene : the mercuric acetate enters the molecule, by substitution. With compounds containing isolated double bonds mercuric acetate behaves in quite a different manner and simple addition compounds of the general formula R-CH(HgOAc)-CHP-R′ are formed, where R and R′ stand for hydrogen or simple or substituted alkyl or aryl groups and P is alkoxyl or acetoxyl group. When this is treated with alkali halides, the acetoxyl group attached to the mercury is substituted by halogen giving rise to the corresponding organo-mercury halides. When the double bond forms part of reactive ring systems containing cyclopropane or cyclobutane rings, the mercuric acetate acts as an oxidising agent as for example in the case of pinene [Balbiano, 1902, 1903] ; but when it occurs in stable five or six membered rings, as in the case of nor-bornylene [Rowland, 1951]—or α terpineol [Sand and Singer, 1902, 1903] stable addition products are obtained. When aromatic compounds with unsaturated side chains are treated with one molecule of mercuric acetate for every double bond in the side chain, at low temperatures, the products formed are mainly addition compounds. Many derivatives of both the above types (organo-mercury acetates and halides) have been described in the literature ; a few of the more important ones are those derived from 2, 6-dimethyl-5-heptene-2-ol [Brook, Rodgman and Wright, 1952 ; Sand and Singer, 1902] ; substituted N-allyl and allyl acetic acid derivatives [Rowland and coworkers, 1951] ; nor-bornylene and 2, 2 diphenyl-4-pentene-1-ol [Rowland, 1951] ; cyclohexene and allied alkenes and ethylenes [Wright, 1950, 1935 ; Wright and coworkers, 1950, 1947, 1940 ; Leucas *et al.* 1939] ; cholesterol [Levine and Spielman, 1940] ; saffrol and eugenol [Priester, 1938] ; Cinnamic acid, saffrole and coumarin [Matejka, 1936] ; and various unsaturated acids including fatty acids [Leys, 1907 ; Ralston, Christensen and Josh, 1937]. Seshadri and co-workers also have reported preparation of some mercurial derivaties with mercuric acetate from coumarins, coumarinic and coumaric acids and esters [Seshadri and Suryaprakasa Rao, 1936] ; cinnamic acid and its derivatives, methyl ethers of coumarinic and coumaric acids [Rangaswami, Subba Rao and Seshadri, 1938] ; Hydroxy and 4-methoxy coumarins [Suryaprakasa Rao, Nageswara Sastri and Seshadri, 1939] amides and imides [Subba Rao and Seshadri, 1939] ; and quinine and cinchonine [Subba Rao and Seshadri, 1940]. In several of the above-mentioned cases, however,

mercuric acetate takes part by substitution (in benzenoid rings or amido or imido groups) though in many of them addition to double bonds in side chains also is involved. The substituted mercury acetates derived from monethenoid compounds are generally viscous unstable liquids which have not been isolated and and characterised in many cases, the corresponding halides are generally well crystallised solids and are more stable.

Material and Methods

During the usual procedure for preparing mercuric acetate addition products, powdered mercuric acetate is added to a solution of the hydrocarbon or other base substance in alcohol with shaking and much mercurous acetate, up to 20-25 per cent of the mercuric acetate taken, is preciptated during this stage. It has been found that by altering the procedure and by using iodine as a catalyst to hasten the reaction, the precipitation of mercurous acetate can be limited to 3-4 per cent of the mercuric acetate taken. The revised procedure is as follows :

ca. 10 g. of camphene (or longifolene or other unsaturated compound) is dissolved in *ca*. 50cc. alcohol and placed in a dropping funnel. Calculated quantity of mercuric acetate (at the rate of one molecule per double bond in the unsaturated compound, with about 3 per cent excess) is finely powdered and suspended in about 150 cc. alcohol in an Erlenmeyer flask and cooled to 25°C. A small amount of the camphene solution is introduced into the flask, well shaken and a little iodine is added at this stage. The rest of the solution is then added slowly (15-25 minutes in all) with vigorous shaking at intervals. The reaction is completed by warming to 60-70°C (water bath) for 10 minutes. The mixture is then cooled to 0°C for half an hour and filtered to remove precipitated mercurous acetate. For isolation of alkoxy (acetoxy) mercuric acetates the filtered solution is diluted with water and extracted with ether, and good yields are obtained in all cases. When the corresponding halides are to be prepared, the theoretical amount of potassium or sodium halide is dissolved in the minimum amount of water, diluted with 3-4 times its volume of alcohol, and added slowly with shaking to the filtered alcoholic reaction mixture, and then the products are allowed to remain in a refrigerator at 0°C for 1-2 days and the precipitated material filtered and recrystallised as usual. A second crop of crystals can be obtained by concentrating the mother liquor and cooling.

Mercuric acetate addition products were prepared by the above technique from raw materials of varying degrees of unsaturation, e.g., ethyl esters of recinoleic acid, castor oil, ethyl esters of groundnut oil, fatty acids, groundnut oil, methyl esters of linseed oil fatty acids, linseed oil, camphene and longifolene. The lognifolene adduct was also prepared by the usual procedure by Harbans Singh and Gulati [1953, unpublished results]. The compounds were tested for fungicidal activity by the Mycology and Plant Pathology Division of the Institute and showed increasing activity with increasing mercury content. These derivatives, however, decomposed on standing in the dark giving a deposit of mercurous acetate and mercury and hence are of little practical use.

Since the activity of the compounds increase with their mercury contents, no practical use would be served by preparing the substituted alkyl mercury halides with less than about 30 per cent mercury content and hence the halide derivatives were prepared only from camphene longifolene and linseed oil fatty acid esters. The yield of crude crystalline mercuric halide derivatives from camphene varied around 55-65 per cent of theory and from longifolene around 50-55 per cent. The yield from linseed oil esters was nearly theoretical.

Since the initial mercuric acetate addition products are formed in a few minutes under the experimental conditions, and the conversion of these to the halides on treatment with alkali halides is practically instantaneous, they are likely to consist entirely of the substituted mercury acetates as indicated by Hugel and Hibou [1929], and this has been confirmed by acetyl group estimations on the mercuric acetate addition products from longifolene, purified ethyl oleate, and methyl esters of linseed oil fatty acids. The estimations were done by hydrolysing the product with 50 per cent sulphuric or phosphoric acids on the water bath for one hour and distilling off the liberated acetic acid with steam, when 95-98 per cent of the acetic acid required on the basis of the acetoxy mercuric acetate formula could be recovered.

The compounds prepared and their physical properties are given in Table I. Their fungicidal properties are being studied at the Mycology and Plant Pathology Division of the Institute, and preliminary studies show activity comparable with the more active commercial preparations available.

TABLE I

Some acetoxy alkyl mercuric halides and their properties

Compounds	m.p. (°C)	Percentage of Hg. cald.	Percentage of Hg. found.
Acetoxy-dihydro Camphene mercuric chloride	110-112	46·6	46·5
Acetoxy-dihydro Camphene mercuric bromide	104-105	42·3	42·8
Acetoxy-dihydro Camphene Mercuric iodide	81-83	38·4	38·1
Acetoxy-dihydro Longifolene mercuric chloride	134-136	40·2	39·8
Acetoxy-dihydro Longifolene mercuric bromide	130-131	36·9	36·6
Acetoxy-dihydro Longifolene mercuric iodide	127-129	34·0	34·4
Acetoxy alkyl mercuric chloride derivative of methyl esters of linseed oil fatty acids.	Viscous liquid	..	44·2

Summary

It has been known for long that mercuric acetate gives organo-mercury-compounds by reaction with unsaturated compounds containing isolated double bonds ; but the fungicidal properties of these compounds have not been studied in detail so far. Investigations show that like all other organic compounds wherein mercury is attached to a carbon atom, these mercurials also show fungicidal activity, the activity in general increasing with mercury content. Improvements in the preparation of these compounds and the preparation and properties of such compounds of high mercury content from some inexpensive and readily available raw materials, e.g., camphene, longifolene and linseed oil fatty acid esters are reported in this paper.

Acknowledgment

The authors thank Dr B. P. Pal, Director and Dr S. P. Raychaudhuri, Head of the Division of Chemistry for a Fellowship which enabled one of them (P. R. M.) to take part in the investigation and also for permission to publish the results.

REFERENCES

Balbiano. (1902). *Ber.*, *35*, 2994 ; (1903). *ibid.*, **36**, 3575

Birks and Wright. (1940). *J. Am. Chem. Soc.*, **62**, 2412

Brook, Rodgman and Wright. (1952). *J. Org. Chem.* **17**, 988

—— (1950). *Can. J. Res.* **28**B, 623

Frear. (1948). Chemistry of Insecticides, Fungicides and Herbicides. Page 251-55

Hugel and Hibou. (1929). *Chimie et Industrie, Spl. No. 296 Feb.*

Leucas, Hepner and Winstein. (1939). *J. Am. Chem. Soc.*, *61*, 3102

Levin and Spielman. (1940). *J. Am. Chem. Soc.*, *62*, 920

Leys. (1907). *Paris Bull. Soc. Chim.*, *1*(4), 633

Matejka. (1936). *Ber.*, *69*B, 274

Priester. (1938). *Rec. Trav. Chim.*, *57*, 811

Ralston, Christensen and Josh. (1937). Oil & Soap., 14, 5

Rangaswami, Subba Rao and Seshadri. (1938). *Proc. Indian Acad. Sci.*, **7A**. 296 303

—— *ibid.*, **7**A, 312-18

Rosemeyer and Wright. (1947). *J. Am. Chem. Soc.* **69**, 697

Rowland. (1951). *J. Am. Chem. Soc.*, **73**, 2381

——, Perry and Gerstein. (1951). *J. Am. Chem. Soc.*, **73**, **91**, 3691

——, Perry and Friedman (1951). *J. Am. Chem. Soc.*, **73**, 1040

Sand and Singers. (1903). *Analen*, 329, 166, 141

—— (1902). *Ber.* 35, 3170

Seshadri and Suryaprakasa Rao. (1936). *Proc. Indian Acad. Sci.* **4**A, 162-69, 630-38

Suryaprakash Rao, Nageswara Sastri and Seshadri. (1939). *Proc. Indian Acad. Sci.*, **9**A, 22-23

Subba Rao. (1952). *J. Sci. Industri. Res.* 11B, 8

—— and Seshadri. (1939). *Proc. Indian Acad Sci.* **10**A, 1-5

—— (1940). *Ibid.*, 11A, 289-97

Wright. (1950). *Chemistry in Can.*, 2(No. 9), 29

—— (1935). *J. Am. Chem. Soc.* **57**, 1993

FODDER VALUE OF TREE AND VEGETABLE LEAVES IN KAIRA DISTRICT

By B. M. PATEL and P. S. PATEL, Institute of Agriculture, Anand

[Received for publication on January 1, 1955
Accepted for publication on June 27, 1956]

(With 1 Text-Figure)

EVERY year during late winter and summer, natural succulent fodders are scarce and mostly dry and over-ripe crop residues which have been exposed to sun and rain are available for feeding cattle. Leaves of trees and vegetable crops which are available during this period, if properly utilised can provide green forage supplement to some extent.

Information regarding the chemical composition, digestibility and the nutritional importance of several tree leaves has been given by Sahasrabuddhe [1930] Gorrie [1937], Zohary [1940], Frances [1943] and Singh [1945]. Momin and Ray [1943] found a definite trend in important constituents of tree leaves at different periods of the year. Chetram and Ray [1943] reported that the digestibility coefficients of some of the tree leaves, viz. *paker* (*Ficus infectoria*), *beri* (*Zizyphus jujuba*) and *pipal* (*Ficus religiosa*) are comparatively lower than those of fodders of similar composition, while Morrison [1949] stated that some better leaves compare favourably with ordinary hay in feeding value. Look [1947] urged farmers in S. Africa to grow some leguminous trees, as their pods being of high nutritive value proved useful for stock feeding in periods of drought. White [1947] stated that the foliage of trees and shrubs are frequently high in minerals. Corbet [1951] gave a brief account of the use of leaves for feeding sheep in times of drought and has recommended breeding and research work to produce nutritious species and strains of fodder trees.

In view of the above facts, it would be interesting and useful to study the chemical composition of leaves of trees and vegetable crops which are likely to be used as fodders in this area.

EXPERIMENTAL

With a view to compare the chemical composition of different tree leaves and to note the seasonal variation in them, monthly samples of the following tree leaves were collected from the same four representative villages in this district for a period of one year : (i) banyan (*Ficus bengaloensis*), (ii) *jamboo* (*Eujenia jambolana*), (iii) *mahuda* (*Bassia longifolia*), (iv) mango (*Mangifera indica*), (v) *neem* (*Melia azadirachta*), (vi) *pipal* (*Ficus religiosa*), (vii) *rayan* (*Mimusops hexandra*), (viii) tamarind (*Tomarindus indica*).

Leaves of *bore* (*Zizyphus jujuba*), castor (*Ricinus communis*), cabbage and cauliflower ; stems and leaves of *suran* (*Amorphophalus companulatus*) and *sheria* (*Crotolaria juncea*) ; and creepers of sweetpotato (*Ipomaea batatas*) *garo* (*Tinospora cordifolia*), and *enter vel* (*Cuscuta refnexa*) were collected during winter months.

For the collection of samples in each village, leaves were plucked from at least 5 trees of the same kind in a manner as done by cattle owners for feeding their cattle. All the leaves were bulked together and a composite sample was taken which formed a representative sample of that particular type of tree leaves from that village. Similarly samples from the other three villages and of the other tree leaves were collected regularly at monthly intervals for a year. Samples of vegetable leaves and creepers were collected during winter months or when usually they were available.

The methods adopted for the analysis of different constituents were those recommended in A. O. A. C. [1950].

Results and Discussion

(*A*) *Tree leaves*

The villagewise results of all the leaves being too many and as their statistical analysis indicated no significant variations in the composition of the same kind of leaves from different villages, they are not presented here. The overall statistical analysis of the entire data is given in Table I.

The data analysed includes the composition of leaves of 9 different trees, collected from the same four villages for 12 months. Thus in all 432 samples were analysed in the present study.

Table I

Overall analysis of variance

Source of variation	D. F.	Mean square					
		C. Protein	E. Ext.	N. F. E.	C. Fibre	P_2O_5	CaO
Villages	3	8·20	3·13	5·77	5·29	0·0021	3·68
Trees	8	442·77**	85·99**	810·15**	470·99**	0·21**	31·52**
V × T	24	5·49	9·11	27·91	19·98	0·037	3·91
Seasons	2	14.86**	1·31	283.65**	285.01**	0·48**	21·64**
S × T	16	4·40	11·63**	21·43	20·99**	0·046*	1·64
SV+STV (Error for sand ST).	54	2·99	1·10	8·63	7·59	0·025	2·75
Months in summer	3	4·52	0·10	11·86	38·09	0·11	4·60**
Months in monsoon	3	11·43	7·29**	15·65	31·23	0·13	0·72
Months in winter	3	16·32*	4·43*	83·95**	83·41**	0·051	6·26**
MV (Error for M)	27	5·40	1·11	12·05	15·87	0·049	0·66
MT in summer	24	3·19	2·09**	8·19	7·20	0·024	1·17**
MT in monsoon	24	3·94*	1·71**	17·26**	8·78*	0·011	1·02**
MT in winter	24	4·59*	1·16*	15·02*	19·46**	0·012	0·81**
MTV (Error for MT)	216	2·58	0·074	8·72	5·86	0·022	0·28

* Significant at 5 per cent and ** at 1 per cent level.

Data in Table I indicate that the composition of the leaves of the same tree from different villages was homogeneous. All the nutrients, except ether extract vary in different seasons. Different tree leaves did not vary in the same way in different seasons. Within months of winter all the nutrients, except phosphate varied significantly. Different trees did not vary uniformly within months of monsoon and winter in all the nutrients, except phosphate.

The average composition of various tree leaves, which varied quite significantly is presented in Table II.

Each result represents the average of 48 samples collected from four villages for 12 months.

TABLE II

The average composition of different tree leaves

(Each result is the mean of 48 results on oven dry basis)

Name of tree	Crude protein	Ether extract	N. F. E.	Crude fibre	Ash	Insoluble ash	P_2O_5	CaO
Banyan	9·7	2·9	50·2	23·2	14·1	5·6	0·42	3·40
Jamboo	8·4	4·3	63·4	17·3	6·6	0·5	0·38	1.82
Mango	7·8	3·8	54·0	21·1	13·3	6·4	0·38	2.93
Mahuda	9·1	3·9	60·4	19·0	7·6	1·6	0·48	2·05
Neem	15·6	4·4	55·7	13·4	11·9	1·2	0·54	3·50
Pipal	9·3	2·7	54·0	17·1	16·8	6·1	0·48	4.09
Rayan	9·3	6·2	53·9	23·3	7·4	0·8	0·49	2.00
Samadi	15·2	3·1	53·9	18·0	9·8	0·7	0·52	3.62
Tamarind	13·5	6·8	52·0	18·1	9·5	1·3	0·55	3.18
Significance (F)								
Villages	1 49	0·34	0·21	0·26	..	..	0·057	0·94
Tree leaves	80·65**	9·44**	29·03**	23·57**	..	..	5·74**	8·06**
S. E. Tree leaves	0·34	0·44	0·76	0·64	..	..	0·03	0·28

** Significant at 1 per cent level.

The statistical analysis of the results showed highly significant differences when the compositions of different tree leaves were compared with one another. On the basis of crude protein content, *neem*, *samadi* and tamarind leaves which have about 15 per cent protein were superior to other leaves which had protein contents varying from 8 to 9 per cent. The ether extract of *rayan* and tamarind leaves was very high (more than 6 per cent) and even the other leaves which contained 3 to 4 per cent ether extract were better nutrients than most of the common fodders and grasses. There was remarkably high content of N. F. E. in *jamboo* and *mahuda* leaves.

Neem leaves were least fibrous. All the leaves were remarkably high in calcium content varying from 2 to 4 per cent.

In general these tree leaves are superior in composition to many non leguminous fodders and the leaves of *neem*, *samadi* and tamarind are comparable even to some leguminous fodders. Of all the tree leaves, *neem* leaves being highest in protein and least in crude fibre with other nutrients in fairly high amount, would be most suitable from the nutritive point of view.

Momin and Ray [1943] in their study of the composition of certain tree leaves reported almost identical results for *pipal*, *neem*, mango, tamarind and *jamboo* leaves. However, the ether extract of all the leaves of this area is somewhat higher than reported by Momin and Ray [1943]. In *pipal* leaves 14 per cent protein as reported by them is comparatively higher than in *pipal* leaves of this area which contain about 9 per cent protein.

Though all the tree leaves are quite rich in their nutrient contents, the digestibility trials with some tree leaves carried out by Chetram and Ray [1943] showed that they were less digested as compared to grasses and fodders of similar composition.

As majority of the tree leaves are available almost throughout the year it would be worthwhile to note their nutritive value during different months or seasons of the year so as to enable cattle owners to know when to utilise them with advantage. Monthly samples of the tree leaves were analysed and their results are combined into 3 groups representing the three seasons (i) summer (March to June), (ii) Monsoon (July to October) and (iii) winter (November to February).

The results showing the seasonal variations in the composition of the different tree leaves are given in Table III. Each result is the average of 16 samples collected from 4 villages for 4 months of the season.

TABLE III

Seasonal variations in the composition of the different tree leaves

(on oven dry basis)

	Banyan			*Jamboo*			*Mahuda*			S. E.
	S	M	W	S	M	W	S	M	W	
C. protein	8·7	10·2	10·1	7·6	8·5	9·1	8·9	8·9	9·5	·43
E. extract	2·9	2·9	2·8	4·3	4·5	4·3	3·3	3·7	4·6	·26
N. F. E.	51·9	48·2	50·6	63·1	63·4	63·6	61·5	60·0	59·8	·73
C. fibre	22·8	25·7	20·9	18·9	17·6	17·0	19·0	20·3	17·7	·69
Ash	13·7	13·0	15·6	6·1	6·3	6·0	7·3	7·1	8·5	
Insoluble ash	5·6	4·0	7·2	0·6	0·4	0·6	1·4	1·1	1·9	
P_2O_5	0·39	0·42	0·46	0·41	0·28	0·44	0·51	0·40	0·54	·04
CaO	3·16	2·95	4·12	1·84	1·78	1·82	1·9	1·77	2·41	·42

TABLE III—(contd.)

Seasonal variations in the composition of the different tree leaves

(on oven dry basis)

	Mango			*Neem*			*Pipal*			S. E.
	S	M	W	S	M	W	S	M	W	
C. protein	7·6	7·8	8·0	15·4	16·4	15·0	9·6	9·2	9·1	·43
E. extract	3·9	4·1	3·2	4·8	4·5	3·8	2·8	2·3	3·0	·26
N. F. E.	54·6	52·6	55·7	56·9	52·1	58·2	56·4	52·0	53·6	·73
C. fibre	20·8	21·1	21·5	13·2	14·9	12·0	16·7	19·9	14·7	·69
Ash	13·2	14·3	11·7	9·4	12·3	11·6	14·6	16·5	19·6	
Insoluble ash	7·2	6·4	5·5	1·1	0·8	1·5	5·2	4·4	8·8	
P_2O_5	0·32	0·33	0·45	0·59	0·48	0·54	0·53	0·44	0·47	·04
CaO	2·98	2·71	3·09	3·34	3·14	4·30	3·41	3·79	5·06	·42

	Rayan			*Samadi*			Tamarind			S. E.
	S	M	W	S	M	W	S	M	W	
C. protein	8·6	9·4	9·8	14·9	14·7	16·1	13·0	14·0	13·5	·43
E. extract	6·2	6·5	5·8	3·2	2·8	3·3	7·8	6·0	7·1	·26
N. F. E.	54·6	52·7	54·3	55·5	52·6	53·5	53·3	49·7	53·1	·73
C. fibre	23·2	24·5	22·3	17·1	20·2	16·7	16·2	21·0	17·2	·69
Ash	7·4	6·9	7·8	9·3	9·9	10·3	9·6	9·2	9·3	
Insoluble ash	0·9	0·5	1·2	1·0	0·4	0·8	1·2	1·1	1·1	
P_2O_5	0·46	0·47	0·55	0·59	0·34	0·62	0·56	0·49	0·59	·04
CaO	1·94	1·76	2·29	3·34	3·42	4·04	2·98	2·56	3·48	·42

S = Summer M = Monsoon W = Winter

S. E. is the standard error of a seasonal mean for each type of tree leaves.

All the data regarding the monthwise and seasonwise composition of these tree leaves were subjected to statistical analysis (Table I). The variations between the composition of the different tree leaves were highly significant. The various nutrients except ether extract in the same kind of tree leaves varied significantly during the different months and seasons. (Table IV).

Each result in Table IV is the average of 36 samples of 9 kinds of tree leaves collected from the same four villages.

TABLE IV

Average composition of the tree leaves in different months and seasons

(Each result is the mean of 36 results on oven dry basis)

Month	Crude protein	Ether extract	N.F.E.	Crude fibre	P_2O_5	CaO
March	10·12	4·37	57·17	17·24	0·52	3·25
April	10·96	4·26	55·78	19·26	0·54	2·50
May	10·38	4·37	56·30	19·54	0·44	2·49
June	10·58	4·37	56·41	18·52	0·44	2·70
Summer	*10·51*	*4·34*	*56·42*	*18·64*	*0·49*	*2·74*
July	10·56	4·12	54·52	20·66	0·46	2·60
August	10·93	3·53	53·33	21·81	0·35	2·57
September	11·83	4·41	53·04	20·07	0·36	2·68
October	10·73	4·55	53·96	19·67	0·45	2·89
Monsoon	*11·01*	*4·18*	*53·71*	*20·56*	*0·41*	*2·68*
November	11·43	4·00	54·72	19·72	0·55	2·76
December	11·90	3·86	54·06	18·29	0·53	3·58
January	10·67	4·54	56·37	19·63	0·52	3·51
February	10·45	4·53	57·51	16·26	0·46	3·61
Winter	*11·11*	*4·23*	*55·72*	*17·81*	*0 52*	*3·38*
Significance (F).						
Months	13·22**	1·03	4·32**	5·67**	7·45**	6·33**
Season	3·38*	0·11	13·24**	13·58**	10·35**	13·19**
S. E. (Months)	0·16	0·31	0·73	0·68	0·02	0·17
S. E. (Seasons)	0·17	0·28	0·38	0·38	0·02	0·11

* Significant at 5 per cent level. ** Significant at 1 per cent level.

Table III shows that in summer the protein content of all the leaves except of *neem* and *pipal* are lowest. In monsoon, most of the leaves, though comparatively high in protein, are low in N.F.E. by about 5 to 10 per cent in mineral contents by 20 per cent and more fibrous to the extent of 15 per cent than in the other seasons. In winter the leaves are superior in all the nutrients in comparison to their composition either in monsoon or summer is evident from Fig. 1. In summer not only the composition is poor but as shown by Momin and Kehar [1947] the leaves in the

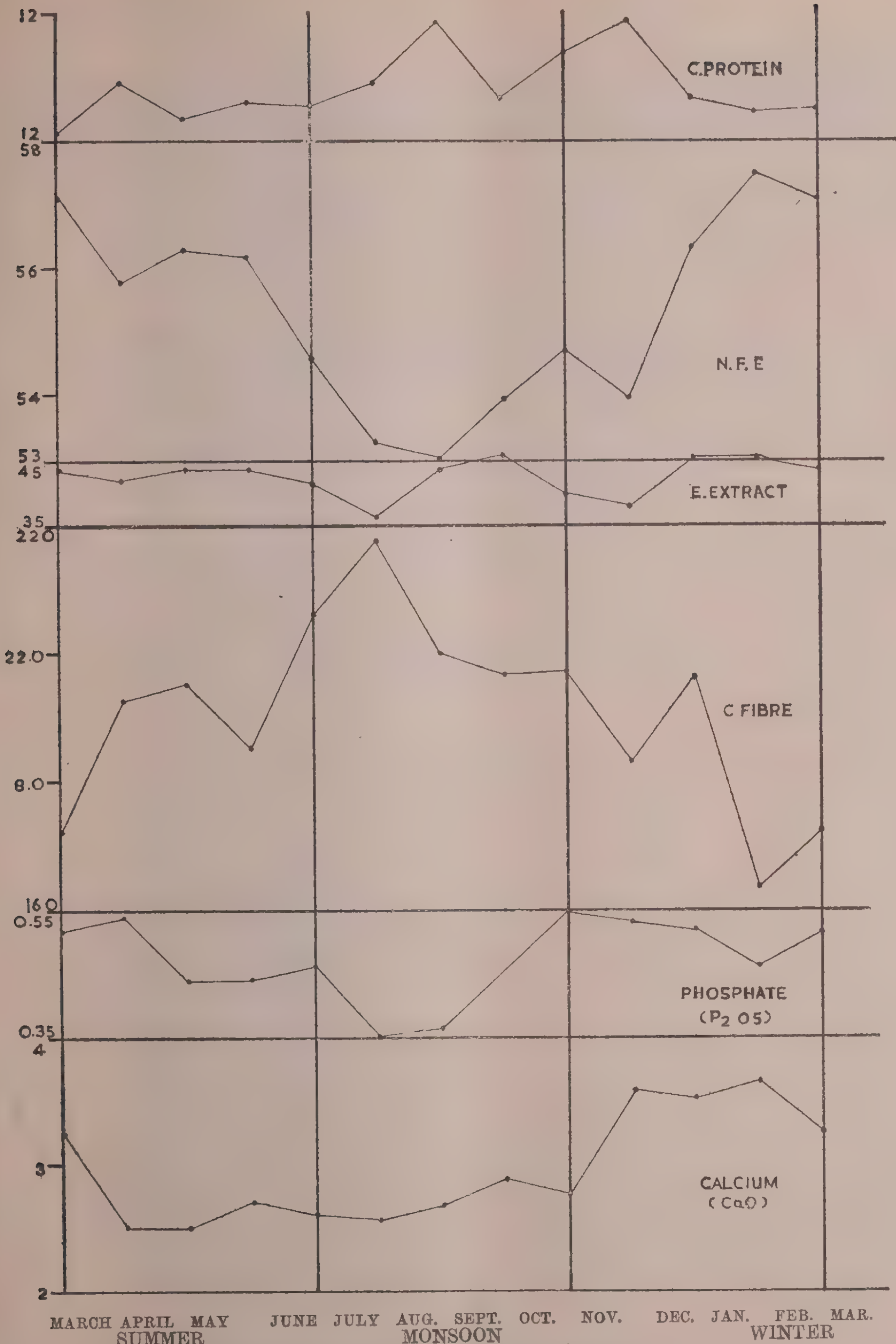


FIG. 1—Seasonal Variations in the Composition of the tree—leaves

shedding stage, which is generally in late winter and summer, are poor in digestibility to the extent of nearly 50 per cent. The results, therefore, suggest that it would be more advantageous to utilise tree leaves for feeding cattle during winter months.

(B). *Leaves of vegetable crops and creepers*

The analytical results of leaves of different vegetable crops and creepers which were collected during the winter season from different villages are given in Table V.

TABLE V

Composition of leaves of vegetable and other crops and creepers

(Average of number* of samples on oven dry basis)

Leaves and creepers	Crude protein	Ether extract	N.F.E.	Crude fibre	Ash	Insoluble ash	P_2O_5	CaO
Bore (22)*	12·9	3·0	55·7	18·3	11·1	1·1	0·53	3·02
Castor (12)*	24·4	5·7	46·9	10·2	12·7	1·2	1·03	3·77
Cabbage (5)*	20·0	3·6	38·4	10·1	27·9	4·8	1·04	4·53
Cauliflower (13)*	18·3	3·5	42·8	10·5	24·8	1·8	1·34	6·29
Suran stems and leaves (2)*	15·3	3·3	50·9	14·2	16·2	1·5	1·86	2·13
Sheria stem (3)*	15·0	5·8	51·1	19·9	8·2	0·8	1·14	2·91
Sweet potato creepers (2)*	17·2	3·4	43·4	19·3	16·7	2·5	1·23	2·77
Garo creeper (4)*	19·9	2·4	61·9	17·3	7·5	0·8	1·29	1·59
Anter vel (10)*	8·0	2·8	62·4	19·2	7·6	1·1	1·28	0·80

Table V shows that the above fodders are quite rich in all the nutrients including minerals and many of them are quite comparable to several grains or concentrates. Other fodders or concentrates are generally rich either in calcium or phosphate while it is remarkable that these leaves and creepers are quite rich in both calcium and phosphate.

Castor, cabbage and cauliflower leaves, having protein percentages varying from 18 to 24, calcium as high as 4 to 6 per cent as CaO, phosphate content more than one per cent as P_2O_5 and being comparatively rich in other nutrients and low in crude fibre, could be superior to many of the concentrates. Moreover, these leaves are not poor in their digestibility like the tree leaves which are low in digestibility. Nehring and Schramm [1952] have shown that cabbage and cauliflower leaves are quite nutritious and easily digested. Stems and leaves of *suran* and *sheria* and creepers of sweet potato have 15·0 to 17·2 per cent protein and are quite rich and well balanced in calcium and phosphate. *Garo* creepers and *anter vel* having about 62 per cent N.F.E. would naturally yield high amount of T.D.N.

It appears that feeding of such fodders can help to replace considerable amount of concentrates and at the same time might be more advantageous than feeding concentrates. In other words these fodders not only can supply equivalent amount of nutrients on dry basis as some of the concentrate mixtures but being green would also supply considerable amount of carotene, ascorbic acid and other vitamins. The results thus indicate that all such leaves and creepers are of considerable value in practical feeding of cattle.

SUMMARY

A study of the nutrient contents of some of the tree leaves indicated that *neem*, *samadi* and tamarind leaves were comparatively rich in protein and minerals ; *rayan* and tamarind leaves rich in ether extract, *jamboo* and *mahuda* leaves outstandingly rich in N.F.E., *pipal* leaves highest in calcium content and mango and *jamboo* leaves are poorest in protein and minerals.

Neem leaves were rich in all the nutrients and are least fibrous and *samadi* and tamarind leaves follow them in their nutritive value.

With regard to the seasonwise composition of the leaves the protein content was least in summer and the N.F.E. and phosphate contents are least in monsoon having maximum amount of crude fibre. The leaves in winter are superior to those in summer or monsoon.

Vegetable leaves and creepers are comparable to some of the good concentrates in their nutrient contents. They were remarkably high in protein, calcium and phosphate.

REFERENCES

Chet Ram and Ray, S. C. (1943). The tree leaves as cattle fodder. *Indian J. Vet. Sci. and Anim. Husb.* **13**, 191-195

Corber, H. A. (1951). *Fodder trees.* Suggestions for their wider use. P. 16. Published by Imperial Printing Co. Ltd. Perth W. Aus.

Francis, W. D. (1943). Edible trees and shrubs. *Qd. Agric. J.* **57**, 215-16 ; 349-50

Gorrie, R. Maclagan (1937). Tree lopping on permanent basis. *Indian Forester* **63**, 29-31

Look, E. E. M. (1947). Three useful leguminous fodder trees. *Emg. S. Aft.* 22. 7-12 and 24. (Herbage Abstract June 1947.)

Methods of Analysis (1950). *A.O.A.C.* Washington, D. C. 7th Edition

Momin, S. A. and Ray S. C. (1943). Tree leaves as cattle fodder. *Indian J. Vet. Sci. and Anim. Husb.* **13**, 183-190

Momin, S. A. and N. D. Kehar (1947). *Proc. Ind. Sci. Congr. Physiol. Sec.* P. 43

Morrison F. B. (1949). *Feeds and feeding.* Morrison Publishing Co. 21st Edition

Nehring, K. and W. Schramm (1952). Composition and feeding value of waste feeds from vegetable market gardens. *Arch. Tierirnahrung* 3, 102-121 (Nutrition Abs. & Rev. (1953) 23, 748.)

Singh, H. (1945). Some useful wild plants of Delhi Province. *Indian J. of Agric. Sci.* **15**, 297-308

Sahasrabuddhe, D. L. (1930). Leaves, stems, roots, and silage cattle feeds of W. India. *Bulletin No. 161*, 18

Whyte, R. O. (1947). The *use and misuse of shrubs and trees as fodder*. Imperial Agricultural Bureaux, Aberystwyth, Great Britain.

Zohary, M. (1940). Trees of Northern Arabia and Syrian desert. *Palest. J. Bot.* **1**, 143-6

GROWTH STUDIES ON AND NUTRIENT UPTAKE BY CIGAR TOBACCO—I

By K. G. TEJWANI, C. K. RAMAKRISHNA KURUP, and K. V. VENKATRAMAN

Central Tobacco Research Institute, Rajahmundry

[Received for publication on May 21, 1956
Accepted for publication on July 30, 1956]

(With 2 Text Figures)

A study of the growth pattern of the cigar tobacco plant as grown in South India was undertaken as the information resulting therefrom would be primarily useful in formulating adequate fertilizer practices with particular reference to the quantity, source and time of application of fertilizers and secondarily of theoretical interest. Similar studies have been made by Davidson [1895], Garner *et al.* [1934], Morgan and Street [1935] and Vickery *et al.* [1935] on tobacco grown in the U.S.A.

MATERIAL AND METHODS

Cigar tobacco seedlings [of the local variety *Vellavazhai*] of eight weeks growth and having three leaves and a growing point were selected and transplanted on ridges at a spacing of 2½ ft. between rows and 2 ft. between plants. To avoid incidence of gaps the seedlings were transplanted in duplicate, one of which was removed after establishment [12 days after transplanting]. In the first year (1952-53) the crop received a basal dose of farmyard manure at the rate of 10 short tons and sulphate of ammonia at 50 lb. nitrogen per acre. The farmyard manure was broadcast a fortnight before transplanting and the sulphate of ammonia at the time of transplanting. In the second year (1953-54) farmyard manure and sulphate of ammonia were applied just before transplanting. The crop received one weeding (weeding includes a shallow hoeing) and mummatti digging (i.e., a deep hoeing and earthing up) 3 and 6 weeks after transplanting respectively. The crop was topped at 14 leaves soon after the inflorescence had emerged about 10 weeks after transplanting. The crop was irrigated from a well. Samples of plants were collected for study at weekly intervals. A separate plot was assigned to each sampling date in a simple randomised block design in which four replications were provided.

The following observations were taken at weekly intervals, the first observation being taken 2 weeks after transplanting when the transplanted seedlings had completely established themselves :

1. Total leaf area of the plant.
2. Accumulation of green and dry matter.
3. Height of stalk.
4. Number of dead old leaves and new leaves produced.

The total leaf area of the plant was obtained by summation of the area of individual leaves on the plant. When a leaf matured and died, its final area was calculated and added to obtain the total leaf area for all the later weeks. The area of each leaf was obtained by measuring the length and breadth of the leaf and then calculating from the regression equations worked out by the authors.*

Each weekly sample for the estimation of green and dry matter consisted of 40 plants, selected in equal numbers at random from the plots assigned for the particular sampling date in all the four replications. The plants were uprooted, the roots cut off. The leaves were primed and the green weight of leaves and stalks recorded. The stalks and leaves were later dried in a steam oven at 95°C and weighed dry.

When a leaf from a particular position on the stalk matured prior to the date of uprooting, the corresponding leaves from all the plants in the sample were primed before they turned yellow and weighed green and after oven drying. This weight was added to the weight of the leaf samples of subsequent weeks to obtain the total green and dry matter produced by the plant.

The weekly observations on the number of dead leaves on the plant were taken on the entire effective population in the whole experiment. Bottom leaves that had dried and died during the week were counted and removed at the time of each observation. Observations of the weekly emergence of new leaves were taken on the 16 plants selected for measurement of leaf area.

Results

The results are summarised below :

Table I

Leaf area (sq. inches) of cigar tobacco plant

(Average of observations on 16 plants)

Growth period	Weeks after transplanting	1952-53			1953-54		
		Average leaf area per plant	Weekly increase in area	Growth in each period as percentage of ultimate area	Average leaf area per plant	Weekly increase in area	Growth in each period as percentage of ultimate area
Transplanting to weeding† (3 weeks)	2	17·5			9·3		
	3	42·5	25·0	0·77	21·6	12·3	0·32

* Length, breadth and actual area of more than 1,000 leaves of different sizes were measured and regression equations worked out for calculating the leaf area. These data will be published elsewhere.

† Weeding includes a shallow hoeing given three weeks after transplanting.

TABLE I (contd.)

Leaf area (sq. inches) of cigar tobacco plant

(Average of observations on 16 plants)

Growth period	1952-53				1953-54		
	Weeks after trans-planting	Average leaf area per plant	Weekly increase in area	Growth in each period as percentage of ultimate area	Average leaf area per plant	Weekly increase in area	Growth in each period as percentage of ultimate area
Weeding to mummatti digging* (3 weeks)	4	97·3	54·8		56·2	34·6	
	5	207·7	110·4		128·4	72·2	
	6	458·5	250·8	12·77	286·5	158·1	6·75
Mummatti digging to topping** (4 weeks)	7	790·8	332·3		644·7	358·1	
	8	1420·7	629·9		1204·9	560·2	
	9	2191·5	770·8		1981·4	776·5	
	10	2531·4	339·9	63·64	3079·0	1097·6	71·18
Topping to harvesting (3 weeks)	11	3003·6	472·2		3577·4	498·4	
	12	3185·2	181·6		3783·5	206·1	
	13	3274·8	89·6	22·82	3932·2	148·7	21·75

* Mummatti digging is a deep hoeing and earthing up with a spade, given 6 weeks after transplanting.

** Soon after the emergence of inflorescence during the 9th and 10th week the crop is topped.

It will be seen from the above data that the rate of expansion of the leaf can be divided into four stages synchronising with the cultural operations, namely, weeding, mummatti digging and topping done on the crop. When the total area of the leafis plotted against time of growth, usual sigmoidal curve is obtained (Fig. 1) indicating that the increase in the leaf area follows generally the usual growth pattern. The grand period of growth is the from 50th to 70th day after transplanting.

Green and dry matter. The data for green and oven-dry weights for the entire plant, leaf and stalk are summarised in Table II.

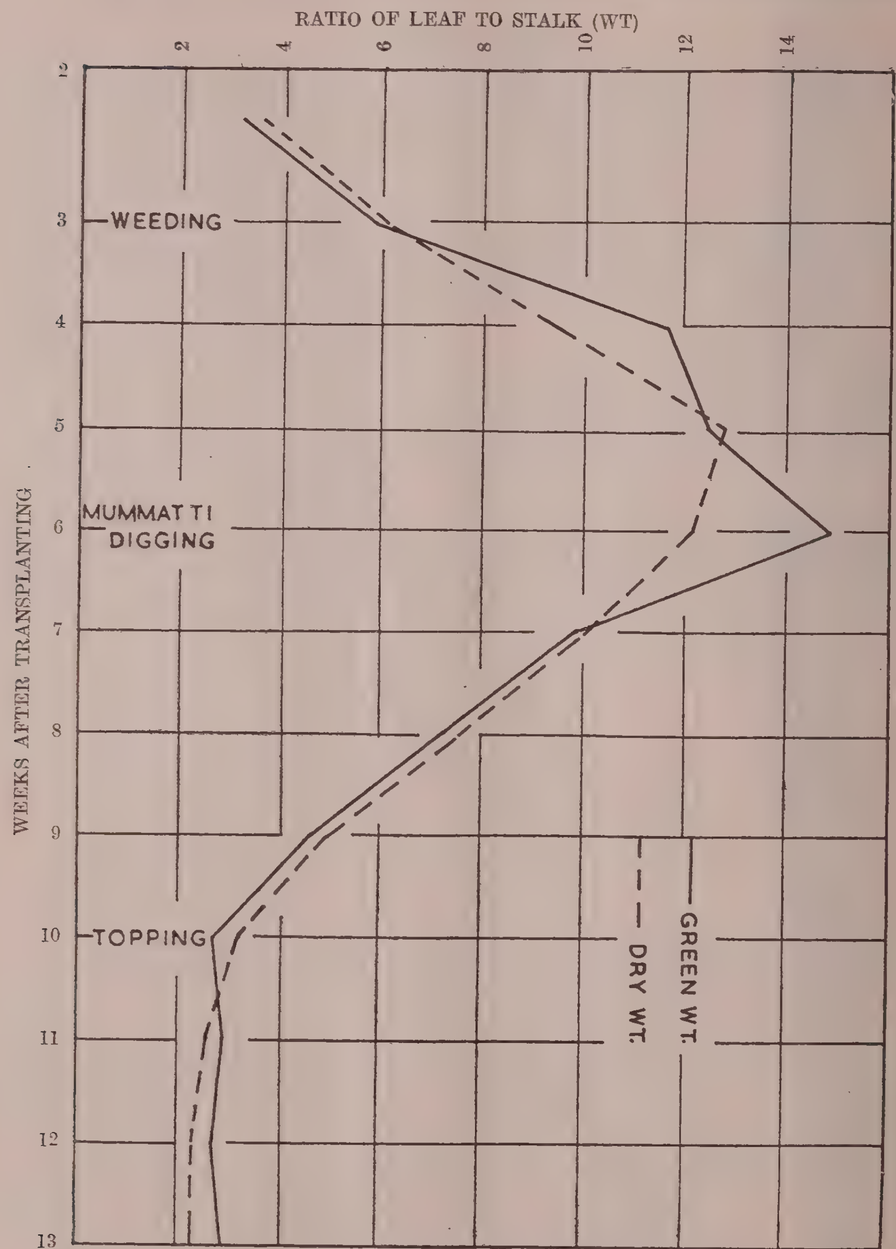


FIG. 1. Graph showing total leaf area and dry matter accumulation at weekly intervals.

TABLE II

Green and dry matter (lb. per acre) of cigar tobacco at weekly intervals

Growth period	Weeks after trans-planting	Whole plant (leaf, stalk, tops and suckers)				Leaf				Stalk			
		Green matter		Dry matter		Green matter		Dry matter		Green matter		Dry matter	
		Yield	Growth in each period as per cent of ultimate green matter	Yield	Growth in each period as per cent of ultimate dry matter	Yield	Growth in each period as per cent of ultimate green matter	Yield	Growth in each period as per cent of ultimate dry matter	Yield	Growth in each period as per cent of ultimate green matter	Yield	Growth in each period as per cent of ultimate dry matter
Transplanting to weeding (3 weeks)	2	49		4·2		37		3·3		12		0·9	
	3	74	0·19	6·7	0·24	63	0·22	5·8	0·30	11	0·11	0·9	0·11
Weeding to Mummatti digging (3 weeks)	4	250		15·9		230		14·4		20		1·5	
	5	865		65·9		800		61·1		65		4·8	
	6	1719	4·31	125·6	4·26	1610	5·48	115·9	5·69	109	0·99	9·6	1·03
Mummatti digging to topping (4 weeks)	7	4828		336·0		4379		305·1		449		30·9	
	8	8749		549·3		7677		484·7		1072		64·6	
	9	18713		1086·9		15344		901·8		3369		185·1	
	10*	30645	75·71	1767·8	58·89	22341	73·42	1346·6	63·62	8304	83·10	421·2	48·77
Topping to harvesting (3 weeks)	11*	33312		1993·2		24804		1441·8		8508		551·5	
	12*	33388		2349·4		24158		1630·0		9120		709·1	
	13*	38207	19·78	2788·7	36·61	28235	20·88	1934·4	30·39	9862	15·80	844·0	50·09

* 10th, 11th, 12th and 13th week yields for total plant include "tops" in addition to leaves and stalks.

* 12th and 13th week yields for total plant include suckers in addition to leaves, stalk and "tops".

* 10th, 11th, 12th and 13th week yields for stalk include "tops".

The data would indicate that the maximum weights of green and dry leaf and total plant are produced during the 9th and 10th weeks after transplanting. The grand period of increase in the weight of the green stalk occurs a week later than that of the leaf or total plant, i.e., during the 10th week. The dry matter in the stalk continues to increase progressively up to the time of harvesting indicating that the stalk continues to grow even after the active growth of the leaf stops. Growth studies on Havana seed tobacco reported by Morgan and Street [1935] and flue-cured tobacco (Chatham variety) at the Central Tobacco Research Institute Rajahmundry, indicate similar trends in the growth of the stalk. The data in Table II would further indicate that, as in the case of leaf area, the production of green and dry matter takes place in four stages synchronising with the cultural operations done on the crop. The crop grows very little up to six weeks after transplanting (the time of mummatti digging) and then accumulates very large quantities of green and dry matter up to topping which is usually done 10 weeks after transplanting. When the quantity of dry matter produced by the whole plant, leaf and stalk are plotted against time of growth, the usual sigmoidal curves are obtained (Fig. 1).

Height of stalk. The data for height of stalk are summarised in Table III.

TABLE III

Height of the stalk

Growth period	Weeks after transplanting	Average height (inches)	Increase in height in each period as percentage of total
Transplanting to weeding (3 weeks)	0	1·66	
	2	1·64	
	3	1·61	*Nil*
Weeding to mummatti digging (3 weeks)	4	1·59	
	5	2·17	
	6	3·03	2·96
Mummatti digging to topping (4 weeks)	7	6·55	
	8	12·55	
	9	30·67	
	10	50·25	97·04

The data would indicate that during the first six weeks after transplanting there is very little increase in the height of the plant. During the 4 weeks between mummatti digging and topping the height of the plant increases 17 fold, i.e. about 97 per cent of the total height is attained during this period.

Number of dead old leaves and new leaves produced. The data for the number of dead old leaves and new leaves produced are given in Table IV.

TABLE IV

Average number of dead old leaves and new leaves emerged per plant at weekly intervals

Growth period	Days after trans-planting	Mean No. of dead old leaves per plant		Mean No. of new leaves emerged per plant		New growth during each period expressed as percentage of ultimate growth	
		1952-53	1953-54	1952-53	1953-54	1952-53	1953-54
Transplanting to weeding	4	0·69	0·85	..	..		
	11	0·38	0·49	..	..		
	18	0·39	0·45	1·38	1·38	6·73	7·10
Weeding to mummatti digging	25	0·43	0·43	1·81	1·38		
	32	0·90	0·38	2·69	1·50		
	39	0·09	0·27	3·25	2·10	37·79	25·62
Mummatti digging to topping	46	1·49	0·44	3·00	2·88		
	53	0·53	1·14	4·13	3·10		
	60	1·12	0·72	4·25	3·88		
	67		0·93		3·13	55·48	67·28
	70	Crop topped	Crop topped	Crop topped	Crop topped		
TOTAL		6·33	6·10	20·51	19·38	100·00	100·00

The death of old leaves does not seem to follow any trend except that after mummatti digging (6 weeks after transplanting) the loss of leaves increases probably due to mechanical injury. The total number of leaves lost and the number of new leaves produced up to the time of topping was almost the same in both the years. The production of new leaves, as in the case of production of leaf area and green and dry matter, takes place in four stages synchronising with the cultural operations done on the crop. Very few new leaves are produced during the first three weeks after transplanting up to the time of weeding. During the next 3 weeks they increase considerably but during the third period—from mummatti digging to topping—their production is the highest.

Discussion

Total growth. The results presented in Tables I to IV indicate that the growth of the crop takes place in 4 phases which are related to the cultural operations given to the crop.

The plant has very little growth during the first phase, i.e., from transplanting to weeding. This period of 3 weeks appears to be taken up by the seedlings mostly for establishment. It may, therefore, be termed as the "establishment phase" of growth.

During the second phase between weeding (which is usually done at the end of the 3rd week after transplanting) and mummatti digging (done at the end of the 6th week after transplanting) about one-third of the total number of new leaves produced by the plant emerge but the plant does not make much growth in leaf area, green and dry weights and height of the stalk. After establishing itself the plant puts forth new leaves for subsequent increased growth. This period may, therefore, be termed as the "transitional phase" of growth.

The growth of the plant in the third phase, between mummatti digging and topping (done at the end of the 10th week after transplanting) is phenomenal. During these four weeks the plant develops more than 60 per cent of the total leaf area, produces 50 to 60 per cent of leaves and accumulates 60 per cent of total dry matter. More than 95 per cent of the total height is also attained during this period. This period may, therefore, be termed as the "active phase" of growth.

During the three weeks of the fourth phase from topping to harvesting the plant completes the growth. The leaves become mature and ready for harvest. This period may, therefore, be termed as the "maturation phase" of growth.

Rate of growth. A large number of workers have attempted to give mathematical expression to the rate of growth and growth curves of plants. Miller [1938] and Bakhuyzen [1926, 1927] have extensively reviewed the literature relating to the rate of plant growth. Hammond and Kirkham [1949] have shown recently that the growth rate of soyabeans and maize is exponential and each straight line segment of the logarithmic curve can be expressed by the usual straight line regression equation. No such attempt has been made for the data reported here as the cultural

operations of mummatti digging and topping have interfered with the normal growth of the plants. The percentage increase in the leaf area ; accumulation of dry matter for the whole plant, leaf and stalk and height of the stalk at the end of each period over the corresponding observation at the end of preceding period are given in Table V.

TABLE V

Percentage increase in leaf area and yield of dry matter at the end of a period over leaf area, etc. at the end of preceding period

——	Leaf area		Dry matter			Height of stalk
	1952-53	1953-54	Total plant	Leaf	Stalk	
Transplanting to weeding	..	..	91	..	..	*Nil*
Weeding to mummatti digging	979	1226	1775	1898	967	88
Mummatti digging to topping	452	975	1307	1062	4238	1558
Topping to harvesting	29	28	58	44	100	Crop topped

It will be seen that the rate of increase in leaf area, accumulation of dry matter in total plant and leaf, is maximum during the second period of growth. The rate is quite high during the third but is very abruptly slowed down during the fourth period. The maximum rate of accumulation of dry matter in the stalk occurs during the third period but is abruptly checked after topping. The growth rates of stalk and leaf do not follow the same trend. In Fig. 2 the ratios of green and dry weight of leaves to those of the stalk indicate that up to six weeks after transplanting the leaves grow faster than the stalk. Afterwards, the growth rate of the stalk increases ; consequently the curve descends. Ten weeks after transplanting, i.e. after topping the ratio remains constant. The increase in growth rate for the height of the plant is nil during the first period while the maximum rate is obtained during the third period.

This study reveals that from the point of yield of leaf and stalk the third period of growth is the most important ; therefore, for successful cultivation of cigar tobacco, attempts should be made to provide optimum conditions to the plant during this period. Plant samples have been collected to study the rate of uptake of various nutrient elements by the crop. The results when available will indicate the source, quantity, and time of application of fertilizers.

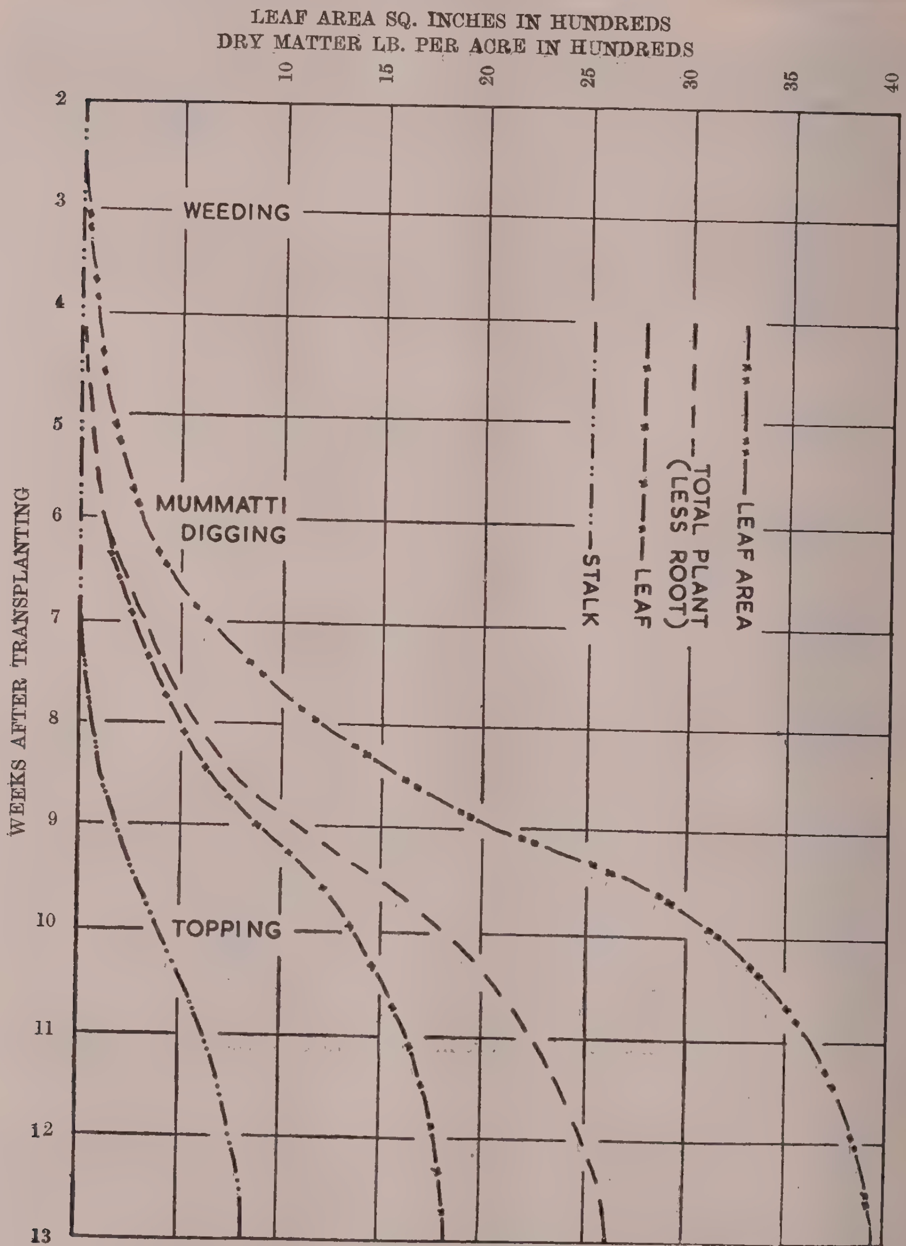


Fig. 2.—Ratio of weight of leaves to stalk at weekly intervals

Summary

Growth characteristics of the cigar tobacco plant as grown in South India have been studied by observing the green and dry weights of the plant, height of stalk emergence of new leaves and leaf area. It is observed that the growth period may be divided into four phases, which may be called the (1) "establishment", (2) "transitional", (3) "active" and (4) "maturation" phases of growth. The "active" phase of growth is the most important from the point of yield. The rate of expansion of the leaf area and accumulation of dry matter by the whole plant and the leaves is maximum during the second phase and that by the stalk during third phase.

Acknowledgment

The authors wish to express their sincere thanks to Dr B. S. Kadam, former Director, Tobacco Research, for giving necessary facilities for conducting the above work at the Cigar and Cheroot Tobacco Research Station, Vedasandur, and to Dr N. R. Bhat, Director, Tobacco Research, for going through the manuscript critically and suggesting several improvements in the text.

References

Bakhuyzen, H. L. Van De Sande (1926). Growth and growth formulas in plants. *Science* **64**: 653-656

——————— (1927). The growth curve in annual plants. *Physiol. Rev.* **7**: 151-187

Davidson, R. J. (1895). Analysis of parts of tobacco plant at different stages of growth. *Va. Agri. Expt. Sta. Bull.* **50**: 35-52

Garner, W. W., *et al.* (1934). The nitrogen nutrition of tobacco. *U.S.D.A. Tech. Bull.* **414**

Hammond, L. C. and Kirkham, Don. (1949). Growth curves of Soyabeans and corn. *Agron. J.* **41**: 23-29

Miller, E. C. (1938). Plant Physiology 1025-1028. McGraw-Hill Book Co., Inc., N. Y.

Morgan, M. F. and Street, O. E. (1935). Rate of growth and nitrogen assimilation of Havana seed tobacco. *J. Agric. Res.* **51**: 163-172

Vickery, H. B., *et al.* (1935). Chemical investigations of the tobacco plant. V. Chemical changes that occur during growth. *Conn. Agr. Expt. Sta. Bull.* **376**

REVIEWS

FLOWERING TREES IN INDIA*

THIS sumptuously produced book is the latest product of Dr. M. S. Randhawa's creative genius. Dr. Randhawa has a versatile pen and has for a long time been writing on various subjects connected with science, folklore, art, painting, etc. Such writings are apart from those resulting from his scientific researches relating to his special subject, viz. the Indian algal flora. Although a highly successful administrator and a competent art critic, Dr. Randhawa has found time to devote himself to scientific pursuits, to make special observations on tree habits in relation to their ecological set-up, and the general distribution of vegetation in this country. By training as well as by temperament, he is specially qualified to undertake the study of flowering trees as related to bio-aesthetic planning, to folklore and to festive occasions. He has even viewed them against the background of geological successions and meteorological changes brought about by the passage of time. Early in his career he took seriously to the study of trees in this country, their foliage, their flowers and their peculiar characteristics, and this interest has continued for more than 20 years now ; the present book is a tangible result of this long arduous study patiently undertaken in brief intervals of time squeezed in between his various official assignments.

From the title it appears that this book deals only with the flowering trees of India. Actually, however, it includes many more subjects than its name signifies. A glance at the table of contents will serve to bring out this point. There are 22 chapters dealing with such divergent topics as forgotten flowers, the pageant of the seasons, trees in modern art, wanderings of plants and highway avenues.

The book begins with the awakening and development of the author's interest in Indian trees and their aesthetics, and goes on to enumerate the cases of some beautiful flowering trees which have suffered neglect and are now not so common as in times gone by. In the succeeding chapter the various seasons have been correlated and harmonised with the floral behaviour in different times of the year. It is followed by a descriptive treatment of trees in modern Indian art and folk songs. There is a brief account of what may be termed as plant introduction. The chapters devoted to bio-aesthetic planning stress that a beautiful environment is essential for a healthy living ; there are suggestions as to the places which could be beautified and how this could be done, and also about conservation of plant and animal life in this country, and creation of natural parks. The subjects of home gardens and avenues for highways and roads have been dealt with at length. There is a special chapter elaborating the carefully planned tree planting programme connected with the landscaping of Chandigarh, the new capital of the Punjab. There are informative accounts of tree planting festivals both in India and other countries. The chapters dealing with trees and their habitat, planting and care of trees, various

*Flowering Trees in India by M. S. Randhawa, pp. 210, price Rs. 15, published by the Indian Council of Agricultural Research, New Delhi, 1957.

types of trees, viz. ornamental or shade or unusual or fragrant ones, are full of technical information which will be found useful even to persons specially trained in botanical science. In addition there is a fairly extensive bibliography arranged subject-wise and a copious index which will be of immense help to the readers for locating particular topics.

As one goes through this book, one is amazed at the wide sweep of the writer's interest—history, art, archeology, folklore, biology, etc. These various disciplines, and many more, have claimed attention of the author, and the outcome of all these varied interests and study in this book. It may safely be looked upon as a product of organic synthesis of many mental projections brought about by the author's multifarious interests and wide reading, and the rich spiritual satisfaction he has gained from his inborn appreciation of the Indian heritage of trees. The book will certainly be reckoned as a distinct and valuable contribution to the existing literature on Indian trees. It has been illustrated with a number of superb paintings, the artistic appeal of which enhances the value of the book; these are some of the best renderings in colour of Indian trees seen in recent times.

Dr. Randhawa wields a facile pen. He writes with warmth and understanding. The style of his writing is such that it easily attracts the attention of the reader and wins his confidence. His unorthodox and sympathetic way of dealing with highly obstruse subjects is at once simple and inviting, drawing even the most casual reader and awakening interest in him.

The book is neatly printed and attractively produced with a pleasing cover jacket. It will not be superfluous to remark that the publication has attained a high water mark of luxurious book production. It will undoubtedly be of great help to the students of botany, agriculture, horticulture, forestry and others interested in tree flora of the country.—U. N. C.

RICE IN INDIA*

RICE in India is a monograph which attempts to summarise knowledge on different aspects of rice in this country, its cultivation, production, marketing and technology. Such a book containing an all-comprehensive account of rice has been in want for a long time and it is satisfying to note that it has at last been produced. Rice happens to be one of the major cereals in this country, and, therefore, a dependable account of this commodity covering the various aspects as indicated above will surely be of great help to the students of botany, agriculture, agronomy and other persons interested in this crop.

*Rice in India by R. L. M. Ghosh, M. B. Ghatge and P. V. Subrahmaniam, pp. 507, price Rs. 21, published by the Indian Council of Agricultural Research, New Delhi, 1956.

The book fills up a distinct gap in our literature relating to this particular crop. The monograph is divided into three parts, each containing a number of chapters. The book has an able foreword from the facile pen of Dr. M. S. Randhawa, Vice-President, Indian Council of Agricultural Research. In addition, there are several appendices.

Part I deals with agricultural aspect of rice and is divided into three sections. Section A consists of a number of chapters including one which serves as a general introduction to the crop, and gives an idea of its history, area and production. The subsequent chapters deal with botany, climate, soils, irrigation, drainage, water requirements, culture, diseases and pests. Section B contains chapters in which are briefly reviewed the results of research work carried out in this country on breeding, genetics, cytology, physiology, agronomy, diseases and pests of rice. Section C deals with extension, viz. seed multiplication, fertiliser distribution, plant protection and Japanese method of rice cultivation, etc. The Part I has also a number of appendices which contain important information relating to rice growing seasons and cultural practices in different States, a list of fungi recorded on rice in India, rice pests, storage pests, improved rice strains and green manuring.

The Part II deals with marketing of rice ; such subjects as supply, utilisation and demand, prices, transportation, distribution, manufacture of rice products, are discussed in some details.

Part III deals with technological aspects of rice processing and nutritional values of rice and rice products and their improvement.

There are lists of selected references appended to Parts I and III which will be useful to readers wanting detailed information from original sources.

The book is very well produced, neatly printed with a good binding, and an attractive cover jacket. It will surely be welcomed by all those interested in various aspects of rice cultivation, marketing and technology, by students, research workers, administrators, businessmen and commercial organisations—U. N. C.

HISTORY OF CHEMISTRY IN ANCIENT AND MEDIEVAL INDIA

By P. Rây

Publisher : Indian Chemical Society (1956). Price Rs. 20

THE History of hindu-Chemistry by Acharya Prafulla Chandra Rây went out of print some years ago and it is gratifying to note that the Indian Chemical Society of which Acharya Rây had been the founder President, has brought out this volume under the editorship of one of his older pupils, Prof. Priyada Ranjan Rây, after incorporating additional material that has been brought to light through recent archæological and historical researches. With the addition of this new material the name has appropriately been changed to "History of Chemistry in Ancient and Medieval India". The study of the History of Chemistry in this volume begins

with the archæological findings of pre-Harappan and Indus-valley civilisation. Evidences of knowledge of chemistry as revealed in practical arts like painted pottery, brick-making, glass-making extraction and working of metals particularly copper, have been discussed in detail. According to experts, as mentioned in this book, this culture flourished during 2500 to 1800 B.C. Later, the historic epoch is influenced by the coming of Aryans. In the development of knowledge of chemistry this period has been divided into Vedic period, the pre-Buddhistic era [800 A.D.], the Ayurvedic period, the post-Buddhistic era [800 to 1100 A.D.], which also includes various practical arts involving knowledge of chemistry as revealed in "Kautilya's Artha Shastra". This period merged into and was followed by "Tantric period" [800 to 1300 A.D.] and "Iatrochemical period" [1300 to 1550 A.D.]. A section, giving an account of chemistry in practical arts as pursued in India till the break up of the Moghul empire and the advent of the British has been added.

A short account of socio-cultural background in each period has been given to facilitate the understanding of the development of chemical knowledge of the time. An abridged version of the "Physico-chemical theories of ancient Hindus" by B. N. Seal, which formed a chapter in the original work by Acharya Rây, has been included, together with original material in Sanskrit and those obtained from Tibetan sources.

An important feature in the volume is the concluding chapter entitled "The Decline of Scientific Spirit in India". Gradual development of the caste-rigidity with the concept of contempt attached to persons engaged in practical arts involving knowledge of sciences, like extraction and working of metals, potteries, tanning of leather and even dissection of human bodies for study of anatomy, undermined the very basis of scientific enquiry.

This book is of immense value to students of history of Science in ancient India and particularly to those interested in chemistry. (S.F.R.)

OUTLINES OF INORGANIC CHEMISTRY

By P. Rây

Published by Indian Science News Assoc. P. (1954). Price Rs. 11

THIS book by Prof. P. Rây has removed a long-felt want of a proper text-book in Inorganic Chemistry for the B.Sc. (Pass) degree of the Indian Universities. Of course, as the author has pointed out in the preface there are in vogue a number of text-books, claiming to serve the above purpose but they can properly be called books on general chemistry rather than on inorganic chemistry. They include in their texts a good amount of physical and applied chemistry, so as to make the general unifying principles of inorganic chemistry rather obscure. As the author has pointed out, in teaching inorganic chemistry a proper balance should be maintained between factual material and theoretical principles in such a way that the students understand the inorganic chemistry as a system. Prof. P. Rây is an Inorganic Chemist of great eminence and has been a very successful teacher in that subject.

The book begins with historical introduction, general principles and theories essential in understanding inorganic chemistry, including classical and modern atomic theories, laws of chemical combination, modern view of valency, of complex compounds, and periodic classification of elements, which is the great unifying principle of inorganic chemistry. This is followed by descriptive chemistry of elements and its compounds. In the last chapter, the author brings out the general unifying principle underlying the properties of elements and its compounds through the modern view of electronic configuration of all the elements in the periodic table.

This book is meant for B.Sc. Pass Course Degree students of Indian Universities but it can be profitably utilised by the Honours B.Sc. and by general M.Sc. students as well. (S. P. R.)

EXPERIMENTAL DESIGN AND STATISTICAL BASIS

By . J. Finney

Cambridge University Press, London (1955). Price 30 sh.

As a writer on statistical methods in biological fields, Dr. Finney needs no introduction. His present publication would be welcomed by biologists seeking aids for a clearer understanding of statistical methods in relation to their particular subjects. 'This book', in the words of the author, 'is intended to provide an introduction to the principles and potentialities of experimental design in a form that can be understood by biologists with no special training in statistics or mathematics'. There are nine chapters in the book covering nearly 160 pages. There is a preliminary discussion of the statistical analysis of experimental data in the form of counts and measurements. This is followed by an account of the various standard experimental designs including randomised blocks, Latin squares, incomplete block designs and factorial arrangements. There is also an interesting chapter on sequential experiments and one on biological assay. The different experimental arrangement and methods of statistical analysis have been amply illustrated with examples showing a considerable bais towards clinical experimentation. The book will provide profitable reading to biologists who have had some grounding in statistical methods and even to statisticians, who wish to initiate themselves in biological applications of these methods; but the author's aim to explain this subject to scientists with no training either in mathematics or statistics can hardly be achieved by the present volume. Scientists of the type he is addressing will not find much of the discussion easy to follow. This is not surprising, considering that the whole comprehensive range of experimental designs is sought to be covered within a short space of 160 pages. The inevitable consequence has been that even bais concepts like standard deviation and degrees of freedom have been dismissed in a couple of lines and the reader has been advised to consult other books for

information on these and other standard statistical terms. A relatively new development in experimental design due to Dr. Finney himself, viz. fractional replication, has been given a section of 5 pages, whereas it would really need a whole chapter. While the present publication is a valuable contribution in its own class, to do full justice to the author's aim would require a volume very much bigger in size. (V. G. P.)

THE UNDERGROUND ORGANS OF HERBAGE GRASSES

By Arthur Troughton

Issued by the Commonwealth Agricultural Bureau (1957), PP. I—IX+163. Price 25 sh.

THIS useful publication on the undergound organs of herbage grasses has been brought out by the Commonwealth Agricultural Bureau. It gives a comprehensive account of the underground organs of grasses, valued for their foliage. The literature relating to roots, rhizomes, corms, etc. of these grasses has been reviewed. The morphology, anatomy and chemical composition of these underground organs have been discussed in relation to the growth of above-ground organs.

The extent to which these underground organs possibly affect agriculture have been discussed from the viewpoint of their relation to the production of herbage and also of the part they play in modifying soil fertility. The effects on the soil brought about by roots or undergound parts as living structures and also as dead organs liable to decay, have been discussed.

Apart from the introduction, the book is divided into four parts. Each part is further subdivided into a number of chapters. The first part is divided into 13 chapters ; the second part into nine chapters ; the third part into three chapters ; the fourth part is not so subdivided but deals generally with the methods used in the study of undergound organs. In addition, there is an appendix which catalogues dry or air-dry weight of roots produced per acre by swards in different countries. A fairly extensive bibliography has been appended. The index will be helpful for reference.

With 10 illustrations and graphs and 55 tables the book is altogether a notable publication on the subject containing a wealth of information, data and other details. It is indeed a valuable addition to the literature on herbage grasses. The book is well produced and neatly printed. (U.N.C.)

PIONEER PEASANT COLONISATION IN CEYLON

By B. H. Farmer

Issued under the Royal Institute of International Affairs,
Oxford University Press (1957), pp. 387. Price 55 sh.

THE author writes in the preface that 'this book is primarily about the efforts which the Government of Ceylon has made in recent years to encourage the settlement in the largely derelict Dry Zone of the Island of Ceylonese peasants hailing from other and more crowded regions or from land hungry villages in the settled parts of the Dry Zone'. The author has been successful in producing quite a detailed study of the colonisation scheme in Ceylon.

The book is divided into three parts. The first part deals with the geographical introduction of the dry zone area and is sub divided into four chapters giving a general statement on the Dry Zone area and its various problems including social and economic ones. The second part is divided in to three chapters dealing with the conditions before initiation of the Government's activities relating to colonisation and the subsequent undertaking of the experiment and its evaluation. The third part is concerned with the activities and problems of the present schemes in the Dry Zone area. In this has also been included a general discussion of various aspects of colonisation and its administration : such topics have been considered as planning, preparation, land use, economic and social problems, etc.

The book is altogether a comprehensive thesis on the subject. In the presentation of the text a great deal of data and details have been incorporated and the discussions evidence the author's firm grip on the problems he has written about. It is well indexed and illustrated with a number of photographs and maps. We may approvingly quote from Lord Soulbury's thoughtful foreword to the book that 'the authorities responsible for the programme of colonisation will find that Mr. Farmer has given most careful and suggestive consideration to almost every aspect of the task'. It will indeed be useful in any region where such programmes have been undertaken or are contemplated.

The book is neatly printed and well produced. (U.N.C.)

AGRICULTURAL ECOLOGY

By Girolamo Azzi

Published by Constable & Company Ltd., 10-12-Orange Street, London, W.C.2, pp. 415. Price 45 sh.

AGRICULTURAL ecology may be looked upon as a new addition to the field of agricultural studies. But in fact it is an application of a recognised branch of science to the study of the responses of crop plant to the stimuli presented by their

environmental complex. Ecology as an independent discipline is undoubtedly included within the orbit of and is an established branch of the biological studies. Agricultural ecology is, therefore, synonymous with the ecology of crop plant and, therefore, it is primarily a study of its reaction to different environmental conditions. As the author says 'agricultural ecology is the study of physical characteristics of environment, climate and soil in relation to development of agricultural plants'. He further writes that 'if environments had no effect on a plant, one plant frog from a single small seed would fill the universe with its mass ; on the contrary if there were complete antagonism between plant and environment, the plant will not be able to thrive at all'. Therefore, it would be appropriate to conclude that 'between plant and environment there exists a natural divergence integrated by the yield which is the final result of the more or less contrasted relationship between them'. As such, the study of agricultural ecology will be considered to be of primary importance to the students of agriculture.

The field of agriculture includes the study of many border-line sciences within the ranges of biology, physics, chemistry, geology, mathematics, etc. This is necessarily so because such studies help in formulating the different factors affecting the growth and reproduction of crop plants and also in evaluating the responses they bring about. The factors may belong exclusively to the soil-climate complex, i.e. the external environment, or to the intrinsic make-up characteristic of the plant. Some sort of a harmonious correlation between these different sets of factors is necessary to ensure a proper growth and development of plants and also their yield which, so far as agricultural plants are concerned, is the primary objective. The author aptly stresses this point when he says that 'in the study of the bio-environmental relationships it is not possible to consider each single factor independently, but all must be treated as a function of all the other factors which influence the yield'.

The book has been divided into several parts, each containing a number of chapters. Part I deals with agricultural climatology, Part II with soil-unit and climate-soil complex, Part III with the yield and ecological characteristics of cultivated plants, and Part IV with factoral combinations and differential analysis of yield. It would appear, therefore, that all aspects of the subject have been dealt with exhaustively and in an adequate manner. Moreover, there is a small chapter on methodology and, in addition a glossary is appended which explains the meanings of various technical terms used in the book. There is also an exhaustive bibliography, to which references pertaining to each chapter are quoted, and an index which will be helpful for the purposes of reference.

This is the first English edition of the book. It will certainly be useful to research workers and students in the field of agriculture, and possibly also those of botany in all countries where English is understood. The language is graceful, simple and precise as it should be in the case of a scientific writing. Reading the book one does not even realise that it is a translation of a book written in another language.

The book is nicely printed with a decent get-up. The book is available in India from Messrs. Orient Longmans Private Ltd., Kanson House, Delhi-Ajmeri Gate Scheme, New Delhi-1.—U.N.C.

THE EIGHTH PLAGUE

By Denys Rhodes

Published by Longmans, Green & Co. Ltd., Pp. 280. Price sh. 13/6

THE locust is not a new phenomenon or a new problem. Mankind has been aware of the existence of the locust and the problems presented by this organism from times immemorial. Although throughout the ages the common man suffered from their activity, so far the locusts as a subject of written work was exclusively reserved for the specialists and those interested in plant protection work. And probably never before was a novel written with the material based on man's activities against locust ; this is possibly a new experiment in fiction writing. The book deals with the subject of war against locusts ; the background provided is that of a fiction. The author has introduced a romantic love story which never allows the interest of the readers to detract. The novel opens with a description of the Locust Control and Research Organisations under which a group of men and women are shown to be ceaselessly toiling during the period of a devastating locust invasion in a fictitious British colony in Africa to beat it off.

One gets an idea of the damage the locust swarm can cause, by the following lines: "Such a swarm continuously feeding itself on crops and vegetation must be capable of starving out the entire human population in any area that it invades." The locust possesses a gluttonous appetite. The whole organisation appears to be fashioned in accordance with the set-up of a military operation; there are such units as Operation Room, Meteorological Room, Transport Lines, Air Wing, etc. Criticisms are levelled against the Organisation both from the public and the Government who characterise the whole operation as a colossal waste. The continuance and existence of the Locust Control and Research Organisation depend entirely on the success attained in destroying the locust. The hero is apparently successful in handling the locust problem in a very satisfactory manner. The plot of the story which has been woven round the locust campaign has been successfully handled and the characters play their respective parts in a manner which lends them personality and charm. The author's method of working up the story compels the attention of the readers and arouses their curiosity to follow its thread closely. The reader's interest never lags.

Apart from the romantic story, the presentation of the subject matter, viz. combating locust invasion, is straight forward and interesting, and its treatment has been made realistic with a wealth of detail relating to the technique employed in fighting the menace and the mental attitude needed for this purpose.

The book is neatly printed, well produced, and is a welcome addition to literature on fiction based on scientific subjects. (U.N.C.)

COMPOSTING

By Harold B. Gotaas

World Health Organisation, Palais Des Nations, Geneva, (1956)
pp., 205. Price £1-5sh.

THE book presents a scientific treatment of information and data relating to the methods of composting refuse material, both urban and rural. The available information is classified under nine heads, viz. (1) decomposition of organic matter; (2) sanitary and agricultural importance; (3) historical development; (4) raw material, quantity and composition; (5) fundamentals; (6) methods and planning for cities; (7) methods for villages and small towns; (8) methods for individual farms; (9) manure and night-soil digesters for methane recovery on farms and in villages. The treatment is clarified with the help of a large number of diagrams and tabular statements.

The book differs from the large number of publications that have appeared on the subject of composts and composting during the last two decades, in that the presentation is scientific, factual and condensed—the reader being referred to 94 good references on the subject, for fuller details on the points referred to in the text. Over 200 pages of such terse presentation make the book a scientific treatise, rather than a popular exposition. This is in keeping with the objective of the monograph, which is mainly to help municipal and sanitary authorities in working out suitable techniques for the disposal of their refuse material. The monograph describes in detail the mechanised methods of composting developed for cities and also the methods recommended for villages and small towns. A useful chapter deals with the anaerobic digestion of refuse materials for production of methane gas and manure; and different types of digesters are described, along with full details of their construction.

The total quantity of refuse and excreta produced in the urban areas of the world is much less than the total quantity of farm wastes and cattle excreta produced in the rural areas. It is a fact that today more compost is produced in the rural areas than in towns. From this point of view, it may be open to question whether equal attention should not have been given in the monograph to the composting of farm and cattle wastes, as given to the composting of urban wastes. This discrepancy is possibly explainable by the fact that the publication was sponsored by a health authority like the World Health Organisation, which is more concerned with the sanitation of urban areas, and not by an agricultural authority like the F.A.O., whose emphasis would lie in the production of more and better manure from all sources.

Possibly, from the agricultural standpoint, a lacuna in the monograph is the absence of an adequate treatment of the problem of quality and manurial value of composts prepared from different types of refuse material and by different methods of composting. At the present time, when the production of chemical fertilizers is being stepped up rapidly in several countries of the world and vigorous propaganda is being carried on to achieve greater use of chemical fertilizers, a convincing scientific and economic justification for the preparation and use of compost manure is badly needed. The use of organic manures is likely to be increasingly relegated to the background in framing and executing future plans for agricultural production, unless farmers and Governments are convinced by scientific data that organic manures play a vital role in the maintenance of soil fertility, as measured by crop production over an extended period.

Composting methods and processes are but means for the preparation of organic manure and it would not prove an economically attractive proposition for municipalities to undertake compost-production, unless a market exists for the manure produced. It is hoped that in the next edition of the monograph, a summary of the available scientific data relating to the agricultural value of compost manure produced from different sources and by different methods would be included for discussion. (C. N. A.)

MGIPC—M—17 AR/57—3-12-57—2,300.

PRIZES FOR EVOLVING LONG STAPLE COTTON VARIETIES

In order to encourage the breeding of long staple cotton varieties in India which can replace the present imports and lead the country gradually to self-sufficiency in respect of all categories of cotton, the Indian Central Cotton Committee has instituted prizes to be awarded to cotton breeders for successfully evolving long staple cotton varieties. Prizes for the following two categories of cotton will be awarded in the manner indicated below:

Category I : (Cotton with mean staple length exceeding $1\frac{1}{8}$ in.) Two or more prizes of the value of Rs. 5,000 each plus a gold medal of the value of Rs. 500 for each person.

Category II : (Cotton with mean staple length between 28/32 in. and $1\frac{1}{8}$ in.) One award each of the value of Rs. 3,000 plus a gold medal of Rs. 300 for each person in each of the following classes :

(a) Asiatic cotton—irrigated

(b) Asiatic cotton—unirrigated

(c) American cotton—irrigated

(d) American cotton—unirrigated

While evaluating the merits of a strain to qualify for the award, the primary emphasis will be given to the fibre quality of the strain but due importance will be given to other characters also, e.g. yield, ginning percentage and resistance to pests and diseases.

Other details regarding the prizes can be had from :—

The Secretary,
Indian Central Cotton Committee,
14-Nicol Road, Ballard Estate,
BOMBAY.

HERBAGE ABSTRACTS

AND

FIELDCROP ABSTRACTS

———:0:———

These two quarterly journals, prepared by the Commonwealth Bureau of Pastures and Field Crops, Hurley, England, are composed of abstracts from the world's current scientific literature. HERBAGE ABSTRACTS deals with grasslands, fodder crops and their management and FIELD CROP ABSTRACTS with annual field crops, including rice. Both Journals include a review article with each number as well as abstracts dealing with crop husbandry, varieties, crop botany, control of diseases, pests and weeds and a section devoted to book reviews and notices.

For these engaged in agricultural research or in the giving of agricultural advice or information, the reading of these two journals offers a ready means of keeping abreast of current developments without recourse to the labour of scrutinizing the mass of agricultural publications now appearing in many languages. The annual subject and author indexes, dating from 1930 and 1948 respectively, form a valuable source of reference to past work.

The price of each Journal (with index) is 50*s*. per annum, post free. Orders should be sent to Commonwealth Agricultural Bureau, Central Sales Branch, Farnham Royal, Bucks, England.

The Editorial Board, in its work of examining papers received for publication, is assisted in an honorary capacity by a large number of scientists working in various parts of India.

Editorial communications including books and periodicals for review should be addressed to the Secretary, Indian Council of Agricultural Research, Publication Section, New Delhi. Communications regarding subscription *copies of the Journal* and advertisements should be addressed to the Manager of Publications, Civil Lines, Delhi.

Instruction to Authors

Articles intended for *The Indian Journal of Agricultural Science* should be accompanied by short popular abstracts of about 300 words each.

In the case of Botanical and Zoological names the International Rules of Botanical Nomenclature and the International Rules of Zoological Nomenclature should be followed.

References of literature, arranged alphabetically according to authors' names, should be placed at the end of the articles, the various references to each author being arranged chronologically. Each reference should contain the name of the author (with initials), the year of publication, title of the articles, the abbreviated title of the publication, volume and page. In the text, the reference should be indicated by the author's name, followed by the year of publication enclosed in brackets. When the author's name occurs in the text, the year of publication only need be given in brackets. If the reference is made to several articles published by one author in a single year these should be numbered in sequence and the number quoted after year both in the text and the collected references.

If a paper has not been seen in original it is safe to state 'original not seen'. Sources of information should be specifically acknowledged.

As the *format* of the journal has been standardized, the size adopted being crown-quarto (about $7\frac{1}{4}$in. $\times 9\frac{5}{8}$ in. cut), no text figure when printed should exceed $4\frac{1}{2}$ in. $\times 5$ in. Figures for plates should be so planned as to fill a crown-quarto page, the maximum space available for figures being $5\frac{1}{2}$ in. $\times 8$ in. exclusive of that for letter press printing.

Copies of detailed instructions can be had from the Secretary, Indian Council of Agricultural Research, New Delhi.

PRINTED IN INDIA BY THE MANAGER, GOVERNMENT OF INDIA PRESS, CALCUTTA AND PUBLISHED BY THE MANAGER OF PUBLICATIONS, CIVIL LINES, DELHI, 1958